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The activities of the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) have been supported since 1992 by Grant No. DAMD17-92-J-2003 from the U.S. Army Medical Research and Development Command. This report presents a summary of these activities for the grant period from April 1, 1992, through May 30, 1994, including the period covered by a six-month no-cost extension to November 30, 1994. During this grant period the CMNR has met from three to six times each year in response to issues that are brought to the Committee through the Military Nutrition Division of the U.S. Army Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts. The CMNR has submitted seven formal reports with recommendations to the Assistant Surgeon General since April, 1992 and has two workshop reports and a letter report currently under preparation. These reports are summarized in the following activity report with synopses of additional topics for which reports were deferred pending completion of military research in progress. This activity report includes as appendixes the conclusions and recommendations from the seven reports and has been prepared in a fashion to allow rapid access to Committee recommendations on the topics covered over the time period.

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COMMITTEE ON MILITARY NUTRITION RESEARCH

ACTIVITY REPORT 1992–1994

INSTITUTE OF MEDICINE

Committee on Military Nutrition Research

Activity Report

April 1, 1992
through
November 30, 1994

Food and Nutrition Board
INSTITUTE OF MEDICINE

Prepared by

Bernadette M. Marriott and Paul Thomas

NATIONAL ACADEMY PRESS
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competencies and with regard for appropriate balance.

This report presents a summary of activities of the Committee on Military Nutrition Research (CMNR) from April 1, 1992, through November 30, 1994. Many of the activities mentioned here have resulted in reports that were previously published or submitted as letter reports to the sponsor and as such were reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. This activities summary has not been separately reviewed and represents an overview of all activities during the project period as designated.

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The activities of the Committee on Military Nutrition Research (CMNR) from April 1, 1992, through November 30, 1994, were supported by Grant no. DAMD17-92-J-2003 from the U.S. Army Medical Research and Development Command. The preparation of this report and partial funding for reports produced from October 20, 1994 through November 30, 1994 were supported by Grant No. DAMD17-94-J-4046 from the U.S. Army Medical Research and Development Command through the U.S. Army Medical Research Acquisition Activity.

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Preface

The issues addressed in this report as well as in the previous 5 year report, *Committee Military Nutrition Research: Activity Report 1986–1992*, (Marriott and Earl, 1992), illustrate the diversity of activities addressed by the Committee on Military Nutrition Research (CMNR). This diversity has required the use of a broad range of expertise to respond to the issues brought to the CMNR. The range of scientific disciplines represented on the CMNR has been augmented as necessary through the use of workshops or special advisors to enable the CMNR to bring the degree and breadth of expertise necessary to properly respond to the subject under review. The committee has been pleased with and is very appreciative of the willing participation of the invited participants in these sessions and of their providing written papers which have constituted a major part of the CMNR reports. Many of these workshops have included experts from within the military who have shared their research activities and information. They have been excellent representatives of the quality of research that the military has been conducting on many of these problems.

The military is to be commended for continuing to ensure that the nutritional needs of its personnel are adequately met during the stress of military operations through its support of nutrition and related research. There has also been interest and support for modifications of rations of military personnel consistent with the advice provided by the nutrition and public health leadership in the United States. The CMNR is cognizant of the desire to balance long-term health considerations with the demands of maintaining performance under the environmental extremes of military operations.

The ability of operational rations to help sustain military performance has been the subject of CMNR review since 1982. Field studies have shown the adequacy of nutrient intake other than calories sufficient to maintain the weight and performance of troops in the field. Complex interactions involving palatability of the ration components, convenience, fluid intake, socialization, and physical and psychological stresses that influence the consumption of operational rations are discussed in the publication, *Not Eating Enough, Overcoming Underconsumption of Operational Rations* (CMNR, in press). Further evaluation of these complex factors will undoubtedly continue to be of interest to the military and the CMNR.

We have appreciated the close working relationships with COL David Schnakenberg and Colonel Wayne Askew, who have now retired, and the excellent liaison they provided between the military and the Committee. They greatly assisted the work of the Committee by bringing issues forward for consideration and helping to identify expertise familiar with these problems, particularly from within the armed forces. We look forward to continued close association and guidance from Dr. James A. Vogel and his group at USARIEM.

As Committee Chair, I express my deep appreciation to all of the Committee members who have given their time, dedication, and expertise to the careful analysis of the issues and to developing the conclusions and recommendations of the Committee. I also thank all participants in the many workshops who have greatly aided our activities and assured that the appropriate expertise has been available to the Committee. Finally I wish to express my appreciation to the staff of the Food and Nutrition Board assigned to this activity over the past 3 years.

In particular I acknowledge for myself and the entire committee the outstanding support presently provided to this activity by Bernadette Marriott, Ph.D., Associate Director, Food and Nutrition Board, Institute of Medicine, and her assistant, Donna Allen. They have worked with extreme dedication to update and complete publication of several pending CMNR reports and to assure a timely response to the issues currently under consideration by the Committee. The additional assistance of Paul Thomas and Susan Knasiak with this activity report is gratefully acknowledged.

Robert O. Nesheim, Ph.D.
Chair

Contents

Summary

The activities of the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) have been supported since 1992 by Grant No. DAMD17-92-J-2003 from the U.S. Army Medical Research and Development Command. This report presents a summary of these activities for the grant period from April 1, 1992, through May 30, 1994, including the period covered by a six-month no-cost extension to November 30, 1994. During this grant period the CMNR has met from three to six times each year in response to issues that are brought to the Committee through the Military Nutrition Division of the U.S. Army Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts. The CMNR has submitted seven formal reports with recommendations to the Assistant Surgeon General since April, 1992 and has two workshop reports and a letter report currently under preparation. These reports are summarized in the following activity report with synopses of additional topics for which reports were deferred pending completion of military research in progress. This activity report includes as appendixes the conclusions and recommendations from the seven reports and has been prepared in a fashion to allow rapid access to Committee recommendations on the topics covered over the time period.

Background and Introduction

HISTORY OF THE COMMITTEE

The Committee on Military Nutrition Research (CMNR, the Committee) was established in October 1982 in response to a request from the Assistant Surgeon General of the United States Army. It was first organized within the Food and Nutrition Board (FNB) of the National Research Council's Commission on Life Sciences and in 1988 moved with the FNB to its new administrative home in the Institute of Medicine.

The Committee's mission is to advise the U.S. Department of Defense on the need for and conduct of nutrition research and related issues. Specifically it is charged with identifying nutritional factors that could critically influence the physical and mental performance of military personnel under environmental extremes, with identifying deficiencies in the existing relevant data base, with recommending approaches for studying the relationship of diet to physical and mental performance, and with reviewing and advising on nutritional standards for military feeding systems.

Within this context the CMNR was asked to focus on nutrient requirements for performance during combat missions rather than requirements for military personnel in garrison, because the latter were judged not to differ significantly from those of the civilian population.

Although the 11-member Committee changes through a three year rotation policy, the disciplines represented have consistently included human nutrition, nutritional biochemistry, performance physiology, food science, and psychology. During this reporting period, scientists with expertise in immunology and neuropsychology were added to the CMNR to augment the Committee expertise in response to increased activities of the Army in these areas.

COMMITTEE PROCEDURES

Meetings

Meetings have been of three types. *Full Committee meetings* are scheduled at the request of the Army to review nutrition programs, food products, and specific research projects in various stages of development. At these meetings oral presentations by Army personnel are augmented by written background material on one or more specific items for the Committee on Military Nutrition Research to review. The CMNR subsequently meets in executive session to discuss the materials and write a report to the Army that includes a summary of findings and recommendations. These reports are in the form of letters with attached supporting materials or brief, bound reports. *Subcommittee meetings* are convened by the Committee Chair either to plan future work, write reports, or, at the request of the Army, provide on-site review of research projects where the expertise of the entire Committee membership is not required. Reports drafted by subcommittees of the CMNR are subject to the review and approval of the entire Committee membership prior to completion. *Workshop meetings* are planned when issues have been presented to the CMNR by the Army that require broader expertise than exists within the Committee, or for which the Committee would like additional information or opinions. A CMNR workshop includes presentations from Army and other experts in nutrition and related sciences on an issue relevant to military nutrition research. The invited speakers are chosen for their specific expertise in the topic areas of concern and are asked to provide in-depth reviews of their area of expertise as it directly applies to a series of questions drafted by the sponsor. Speakers subsequently submit written versions of their presentations. These workshops thus provide additional state-of-the-art scientific information for the Committee to consider in their evaluation of the issues at hand. At the conclusion of the presentations, the Committee meets in executive session to discuss the issues and prepare conclusions and recommendations to be included as part of a book-style workshop report for subsequent release to the sponsors and the public.

If a topic is presented by the military where the Committee membership does not feel that they can adequately cover the scientific range required, guest specialists may be invited to augment the Committee expertise and interact with the membership as special consultants for a specific report. If the Committee Chair sees that expertise continues to be needed in a specific scientific area, a new member with expertise in that scientific discipline may be added to the Committee through the normal three year rotation process.

In 1993 the CMNR was selected by the NRC to participate in a pilot study on the use of laptop computers and electronic communication to reduce Committee costs in time and money. All members of the CMNR received a laptop computer with a modem and communications and word processing software on loan from the NRC for their use on Committee business. Committee members are able to access the NRC computer network system via modem and a free telephone line and directly transfer reports or comments to the CMNR staff or each other. The experiment has been very successful as it has enabled Committee members to revise and transmit parts of reports to one another and staff.

Document Format

In 1992, the CMNR formalized the document format types that they used for their reports and developed a standardized report cover. This standardized cover presents a "series effect" to the CMNR reports and makes them readily identifiable as Committee projects. Currently there are four document formats used by the CMNR that reflect the specific needs of the Army.

1. letter with attachments. This type of document is prepared in response to a specific request from the Army for a review of a research project or program which requires a rapid response to be effective. The document must be a short, specific statement of recommendations directed to the Army command for rapid action. These items are research projects that are in progress or specific nutritional concerns that have abruptly arisen. The CMNR is presented orally with the findings and provided with the limited documentation available. The timeliness as well as the concise, highly specific and confidential nature of these documents is specified by the Army when the item is presented to the CMNR. Several examples of letter reports are included in this activity report.

2. brief report with documentation. This document format is typically used in response to a request for review of a food product, packaging process, completed research project, or planned educational program. The Army provides an oral presentation as well as extensive documentation or product specifications. The time frame for the Committee deliberations is several months and the summary and recommendations are bound to the specifications to provide a clear understanding of the iteration of the product, process, project, or program that was reviewed. The 1993 CMNR report: *Review of the*

Results of Nutritional Intervention, Ranger Training Class 11/92 (Ranger II) is an example of a brief report (see p. 27 and Appendix G).

3. workshop proceedings with summary and recommendations. The Army identifies for the Committee at least one topic each year for which they require a thorough review of the current literature by experts in the scientific field coupled with the Committee's recommendations. This requirement is met with a workshop at which experts are asked to make oral presentations that include an overview of the literature and address specific questions posed by the Army. IOM staff compile literature reviews and organize these meetings in close collaboration with the sponsor. The CMNR reviews these presentations and writes a detailed summary and recommendations to the Army. The resulting document includes the Committee's findings with the presentations. The expected turn-around-time for this document type is within 9 to 12 months. An example of a workshop report is the book released in September, 1992: *Body Composition and Physical Performance* (see p. 9 and Appendix E).

4. periodic activities reports. The CMNR is also expected to prepare a bound report at variable intervals (3–5 years) that is a summation of the activities undertaken. No new information is presented in these reports. Typically these reports reflect contract periods and serve as a final report for the contract or contract renewal. This report is an example of the periodic activity report of the CMNR.

Document Review

Subsequent to approval of the final draft of a report by the Committee, and the Food and Nutrition Board, in accordance with National Research Council guidelines, each report, with the exception of the activity reports, is reviewed in confidence by a separate, anonymous scientific review group. In 1992 the CMNR established a separate Review Panel to facilitate the rapid review of Committee reports. This nine-member panel has been initially appointed for a 3-year period. When a report is begun the panel members are alerted and polled as to who among them would be available to review the report. Typically each report has been reviewed by five to seven panel members. The review panel members all have some experience with military nutrition and health issues and therefore have a basic understanding of the concepts under consideration. None are military personnel or have contracts with the military. The review panel has facilitated the speed of report review because the participants are interested and knowledgeable about the issues that come before the Committee. In addition, as panel members they are prepared to consider reviewing reports with a rapid turn around time. As with all NRC report reviews, the comments of the review panel are anonymous.

The Committee then reviews the anonymous comments of this review panel and incorporates their suggestions where appropriate. Staff then write a response to the reviewers with the final report draft and obtain final approval of the report from the review panel. Each Committee on Military Nutrition Research report is thus a thoughtfully developed presentation that incorporates the scientific opinion of the CMNR and the comments of anonymous National Research Council reviewers.

ORGANIZATION OF THIS REPORT

This summary of the activity of the Committee on Military Nutrition Research (CMNR) reflects the period of performance from April 1, 1992, through May 31, 1994, and also includes activities during a six-month no-cost extension of performance through November 30, 1994, as supported by grant no. DAMD17-92-J-2003 from the U.S. Army Medical Research and Development Command to the Food and Nutrition Board for the CMNR program. This report has been organized in topical fashion because the Committee was requested on occasion to participate in reviews of research projects or products during several stages of their development over the course of this grant period. Topics are organized in a quasi-chronological fashion within the overall reports and activities are ordered in chronological order within topics.

A full listing of all Committee meetings and Committee members during the grant period are included as Appendixes A and B. At a number of meetings the CMNR was presented with oral and written reports of research projects in progress or products under development. In a number of instances the Committee deferred a full review of these items until the project was complete. Summaries are provided in the body of the report of all activities in which the Committee was requested to participate from April 1, 1992, through November 30, 1994, regardless of whether a report with recommendations was developed. The Committee typically prepares three styles of reports that correspond with their project requests and meetings: letter reports, brief reports, and workshop reports. In the appendixes full copies of each letter report are included in the order mentioned in the text. For the brief reports and workshop reports, due to length, only the Committee conclusions and recommendations have been included in the appendixes.

The Relationship of Soldier Body Composition to Physical Performance

The military has a major interest in the relationship of body composition to the performance of physical tasks. The relationship is important in decisions to accept or reject recruits for military service and has implications for the individual in regards to retention and advancement within the services. Issues of body composition have financial implications as well for the military, due to the high cost of training replacements when individuals are discharged for failure to meet the established standards. But the discharge of such trained and experienced specialists can affect unit readiness and performance.

The Army contends that all military personnel need to maintain a certain level of physical fitness to preserve combat readiness. Therefore, all are evaluated regularly for height, weight, and/or body circumference; all are also required to perform a test of aerobic fitness. The military services differ in their acceptable standards for weight and physical fitness, but obese personnel in any service who do not lose sufficient weight or body fat to meet these standards will be discharged. However, with the increasing diversity of military personnel in terms of gender, ethnicity, and age, the military questioned whether current height-weight standards were appropriate and applied uniformly in recruitment and retention.

Recognizing the importance of body composition in relation to performance of physical tasks, personnel from the U.S. Army Research Institute for Environmental Medicine (USARIEM) raised this issue with the CMNR in

1989. A task force comprised of USARIEM and CMNR members met in the fall of 1989 to plan a workshop on this topic, and the workshop outline and participants were reviewed by the CMNR at its December 1989 meeting. The invitational workshop was held at the National Academy of Sciences in Washington, D.C., on February 6–7, 1990. Speakers were asked to provide in-depth reviews in their area of expertise as it applied to one or more of the following seven questions:

- Can or should physical performance assessments be used as criteria for establishing body composition standards in the services?
- What is the relationship between body composition and performance?
- Should the services establish a minimum fat-free or lean body mass standard to complement their maximal body fat standard?
- What factors should be considered in setting body composition standards?
- Are performance and body composition standards redundant?
- If performance criteria exist, are weight-fat standards needed?
- How does one rationalize the different uses of body composition for performance, appearance, and health?

The Committee's report, *Body Composition and Physical Performance*, (Marriott and Grumstrupp-Scott, 1992) provides responses to the seven principal questions the CMNR was asked to address and includes recommendations for future research. The report also includes the 12 invited papers presented at the workshop.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the workshop presentations and subsequent discussion by the Committee in executive session, the Committee concluded that the relationship between body composition and physical performance is associated with lean body mass rather than body fat content. No consistent relationship is shown between body fat content and physical performance (at least within the range of body composition exhibited by current military personnel), but there is a direct relationship between such performance (as measured by tests of abilities to lift and carry loads) and the amount of lean body mass. However, body weight standards are desirable insofar as body weight and composition have implications for health that go beyond physical performance. The Committee recommended that the military seriously consider establishing a minimum standard for lean body mass.

The Committee also recommended that consideration be given to developing job-related performance tests, such as lifting and carrying tasks, that are closely related to actual military activities. Such tests would be helpful in developing body composition standards that are more closely related to physical performance of military tasks. Putting such standards into place would make a body composition standard unnecessary in relation to physical performance.

Military personnel are expected to "present a trim military appearance at all times." The Committee could not identify a relationship between a trim appearance and military performance and recommended that if the military maintains such a standard, it should develop objective criteria, to the extent possible, for evaluation of soldier appearance.

The Committee found that the current body fat standards in the military appear to discriminate against women, for the standards allow less excess over ideal weight for women compared to men. Female soldiers are required to have a greater percentage of lean body mass in relation to a gender-specific mean than are male soldiers. The Committee recommended that the accession and retention standards for body weight and fatness in men and women be reevaluated in light of this finding. These standards have since undergone modification (see Marriott and Grumstrup-Scott, 1992, p. 27). It also called for validation of the current body composition standards for the major ethnic groups represented in the military services.

The Committee also recommended that several military centers be identified to which military personnel who face separation from the services for failing to meet body composition standards could be referred. Such centers could perform measures of body composition (e.g., through dual photon densitometry and underwater weighing) that are more accurate than the usual measures based on the use of anthropometric data and formulas developed for populations that may produce significant errors in predicting the body fat for an individual.

AREAS FOR FUTURE RESEARCH

Given the military's pool of volunteer personnel, the Committee recommended research be conducted to develop service-specific standard tests of performance that reflect military activities; identify the relationship of body composition to military and physical performance among men and women; study the relationship, by race and gender, of body composition and fat distribution for long-term health in career military personnel; and identify the relationship of injuries to bone density and lean body mass. In addition, the Committee recommended that the military conduct a retrospective study of its

Medical Remedial Enlistment Program data base to evaluate the health status and performance of its overweight recruits and other personnel. In addition, the CMNR also recommended research into the relationship of body composition to emotional and psychological health in military units; for example, the effects on the morale of a unit containing both overweight and underweight individuals.

* * * * *

The full conclusions and recommendations from this report are included in Appendix E.

Nutritional Requirements for Work in Hot Environments

As a direct result of the movement of the Armed Forces into Saudi Arabia in the autumn of 1990 for Operation Desert Shield (which became Operation Desert Storm in 1991) and the deployment of military personnel in the harsh desert environment of the Middle East, the Committee on Military Nutrition Research was asked by the Division of Military Nutrition, U.S. Army Institute of Environmental Medicine (USARIEM) to review current research pertaining to nutrient requirements for working in hot environments and to comment on how this information might be applied to military nutrient standards and military rations. The scope of this project was defined beyond Desert Shield to include the nutrient needs of individuals who may be actively working in both hot-dry and hot-moist climates.

Relatively few studies over the past half-century have focused on the influence of heat on nutrient requirements and work performance that are relevant to the military. The Committee decided that the best way to review the state of knowledge in this diverse area was through a workshop with invited experts. These experts could provide an update on current knowledge and identify gaps in the knowledge base that might be filled by future research. A subgroup of the committee met in December 1990 to plan the workshop. The invitational workshop was held at the National Academy of Sciences on April 11–12, 1991.

The CMNR was asked to address 11 questions dealing with nutrient requirements for work in hot environments:

• What is the evidence that there are any significant changes in nutrient requirements for work in a hot environment?

• If such evidence exists, do the current Military Recommended Dietary Allowances provide for these changes?

• Should changes be made in military rations that may be used in hot environments to meet the nutrient requirements of soldiers with sustained activity in such climates?

• Specifically, are the Meals, Ready-to-Eat (MREs) good hot-weather rations? Should the fat content be lower? Should the carbohydrate content be higher?

• What factors may influence food intake in hot environments?

• To what extent does fluid intake influence food intake?

• Are there special nutritional concerns in desert environments in which the daily temperature may change dramatically?

• Is there an increased need for specific vitamins or minerals in the heat?

• Does working in a hot climate change an individual's absorptive or digestive capability?

• Does work at a moderate to heavy rate increase energy requirements in a hot environment to a greater extent than similar work in a temperate environment?

The Committee's report, *Nutritional Needs in Hot Environments* (Marriott, 1993), provides responses to the questions the CMNR was asked to address and includes recommendations for future research. The report also includes the 12 invited papers presented at the workshop on topics such as the effects of exercise and heat on gastrointestinal function and nutrient metabolism and requirements; effects of heat on appetite and taste perceptions, smell, and oral sensations; and situational influences on food intake.

CONCLUSIONS AND RECOMMENDATIONS

In a hot environment, water needs are increased due to marked increases in both sensible and insensible losses. Protein requirements may be increased slightly. Based on losses in sweat, additional sodium and other electrolytes may be needed. The few studies examining vitamin needs in hot environments suggest that requirements do not increase. The Committee concluded that the variations in nutrient requirements in such environments are covered reasonably by the current Military Recommended Dietary Allowances (MRDAs, AR 40-25, 1985) and, therefore, the nutrient content of military rations does not need to be changed.

Studies show that appetite is depressed and food preferences and eating patterns are changed in response to short-term and long-term exposure to heat. The reasons for the depressed appetite may be both physical decreased intake to reduce the thermic effect of food and thereby keep body temperature from rising, and psychological, caused by stress and the lack of desire to eat hot foods in hot environments. Adequate hydration appears to be necessary for depressed food intake to return to normal. Therefore, to enhance food intake in hot environments, it may be necessary to make changes in ration components as well as the social situation during meals and time of day for meal service, and ensure that the soldiers are well hydrated. Fortunately, well-trained individuals who are acclimatized to heat and accustomed to endurance exercise experience fewer symptoms of gastrointestinal distress (which would further reduce food intake) than those who are not as well conditioned. Working at a moderate to heavy rate in a hot environment does not appear to increase energy requirements to a greater extent than similar work in a temperate environment.

RECOMMENDATIONS FOR RESEARCH

The Committee made several recommendations for future research within the military related to nutrition for soldiers working in hot environments. Does heat enhance satiety or impair hunger? With the decreased food intake in hot environments and a previous lack of research emphasis, one important need is further investigation of factors that affect food intake in a hot environment. Another is to evaluate whether the reduction in food intake serves a protective metabolic effect, as suggested by animal studies of hyperthermia. More generally, a study is recommended to determine why soldiers don't consume adequate amounts of food under operational conditions regardless of environmental climate, and to evaluate steps that may be taken to ensure consumption of sufficient rations.

Additional research needs include the development and validation of appropriate functional indicators of nutritional status, with an emphasis on vitamins and minerals for which sweat losses are significant. With the lipid peroxidation induced by exercise in a hot environment, the potential role of higher dietary intakes of zinc, vitamin C, and other antioxidants could be explored. Also, studies that focus on gastrointestinal function in the heat are important. Finally, more research is needed to evaluate the impact of adequate mineral intake on physical performance in the heat.

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The full conclusions and recommendations from this report are included in Appendix F.

Military Nutrition Research at the Pennington Biomedical Research Center

Congress mandated in the 1988 Department of Defense (DoD) appropriations bill that $3.5 million be allocated over three years by the Army to fund research programs at Louisiana State University's Pennington Biomedical Research Center (PBRC). Support for the Center was continued in 1992. The PBRC offers opportunities for research on nutrition as it relates to cancer and other chronic diseases, behavior, brain development, and obesity, and to findings at the molecular level. Of particular interest to the Army are issues that affect the nutritional status of Army personnel and their dependents during peacetime because of the overall interactive effects of food, diet, and nutrition on military readiness and preparedness.

The CMNR had been asked to review the research plans of the PBRC funded through the DoD appropriations and had submitted a letter report with their recommendations to the Army in June, 1989. In September, 1991 as the initial grant to the PBRC was nearing completion, the CMNR was asked to review the progress of the PBRC during the three year grant. This review resulted in a letter report that was submitted to the Army in May, 1992. The CMNR again visited the PBRC in June, 1992 to review new research plans as proposed by the PBRC for a renewal of their contract with the Army. The Committee on Military Nutrition Research's role at the meeting on June 3, 1992 was to assist the Army with identifying research activities that fell within the mandate of the appropriation. The responsibility for all decisions regarding the program remained with the Army. For this visit, the CMNR was asked to focus its attention on projects in the areas of neuroscience and menu modification. Summaries of the two letter reports that the CMNR submitted regarding the PBRC programs follow. The full text of the letter reports is included in Appendixes C and D.

REVIEW OF RESEARCH PROGRESS AT THE PENNINGTON BIOMEDICAL RESEARCH CENTER

At the request of Colonel Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM), the Committee on Military Nutrition Research (CMNR) met at the Pennington Biomedical Research Center in Baton Rouge, Louisiana, on September 19–20, 1991. The purpose of this meeting was to assist the Army in reviewing and evaluating the progress on work related to the U.S. Army grant to the Pennington Biomedical Research Center: "Effect of Food, Diet, and Nutrition on Military Readiness and Preparedness of Army Personnel and Dependents in a Peacetime Environment." Several of the Committee members and the Committee Chair, Robert O. Nesheim, had participated in the earlier reviews of the PBRC programs and were particularly cognizant of changes in physical plant and research programs that had occurred.

Prior to the meeting the CMNR reviewed an information paper provided by Colonel Askew and the final report by the grant principal investigator, Dr. Donna H. Ryan. The agenda for the meeting was planned by Dr. Ryan to provide the opportunity for presentation of research results and tour of the facilities, as well as time for the CMNR to meet in executive session to discuss their findings and draft their report.

Findings

The Committee remarked that the Pennington Biomedical Research Center was a very impressive facility having an excellent physical plant for laboratory and clinical research. The CMNR further commented on the considerable progress that had been achieved in staffing and development of research activities since their last visit on December 12, 1988. This has been made possible by financial support from the U.S. Army, the U.S. Department of Agriculture, and grants from the National Institutes of Health, and other sources. In addition, the state of Louisiana has provided ongoing support at a level of $4.1 million. The Committee commented that the vision and leadership of the newly appointed director of the PBRC, Dr. George Bray was clearly evident in the impressive accomplishments of the Pennington Center in such a short time period. The Committee found that there was effective management support and guidance for the development of activities related to this grant through the leadership of the principal investigator, Dr. Donna H. Ryan.

Conclusions and Recommendations

The Committee on Military Nutrition Research reviewed the five projects supported by the grant and provided individual reviews of each area. These are detailed in the letter report (see Appendix C).

Generally, the Committee was impressed with the quality of the research activities at the Pennington Biomedical Research Center given the constraints of essentially starting from a zero base in equipping the facilities, recruiting staff, and initiating research activities, and felt that the funds provided by the U.S. Army grant had been effectively deployed. The CMNR would encourage continued financial support by the U.S. Army of those activities which have been and can continue to be relevant to the military, namely the Clinical Research Laboratory and the stable isotope activity. Further, support of the area of nutrition and behavior should continue with attention to developing a project with greater focus and hence military relevance.

It was the understanding of the CMNR that the Fort Polk Heart Smart Project had been completed, and that future funding was not planned under this program. The CMNR concurred with this position and also suggested that a thorough review of the results of this study and delineation of desired objectives, including inclusion of methodology to evaluate long-term outcomes, be conducted prior to consideration of implementation.

The Committee described a number of limitations of the research progress on the menu modification project and concluded that this project, if continued, should be conducted in a military facility where the staff was more familiar with the military menu and procurement systems in order for a practical program to be developed.

REVIEW OF THREE RESEARCH PROPOSALS FROM THE PENNINGTON BIOMEDICAL RESEARCH CENTER

At the request of the COL Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, USARIEM, who is Grant Officer Representative for the Army for CMNR, a subcommittee of the CMNR met at the Pennington Biomedical Research Center (PBRC) in Baton Rouge, Louisiana on June 3, 1992. The purpose of this meeting was to assist the Army in discussing plans for three projects that were proposed as part of USAMRDC Grant no. 17-92-V-2009 to the PBRC: "Military Nutrition Research: Six Tasks to Address Medical Factors Limiting Soldier Effectiveness." The chair, Robert O. Nesheim, and members of the Committee who were either knowledgeable about the scientific areas addressed by the research proposals, or who had been involved in previous reviews of research at the PBRC, attended the meeting.

Prior to the meeting, the CMNR reviewed: (1) preliminary research proposals prepared by the scientific staff and principal investigator, Dr. Donna Ryan; (2) an information paper and background materials, including the Grant Statement of Work, previously provided by COL Askew; (3) the final report on the previous USAMRDC Grant to the Pennington Center submitted by Dr. Ryan; and (4) two earlier reports prepared by the CMNR at the request of the USAMRDC reviewing this same research program in 1989 and 1992.

The agenda for the meeting was arranged by Dr. Ryan to permit time for the scientists from the PBRC to orally present their research plans and for the CMNR to tour new laboratories at the Center. At the end of the meeting, the Committee met in executive session to discuss the presentations, review the written materials in more detail, and draft their report.

Findings

The Committee commented on the rapid expansion of facilities and staff of the PBRC under the leadership of Drs. George Bray and Donna Ryan. In the nine months between visits of the CMNR, the Center had continued to grow and provides an excellent environment for scientific study and research support services needed by the Army research programs. The Committee commended Drs. Bray and Ryan for their vision and leadership.

Conclusions and Recommendations

The Committee on Military Nutrition Research reviewed the three research proposals and provided specific comments on each project (see Appendix D). The CMNR expressed general concern about the lack of focus of the projects on the nutritional relevance to the military. The Committee also stated that the objectives and protocols of the projects required more specificity and detail in order to clearly present the research objectives and plans. This was particularly true for the clinical nutrition project, where the CMNR raised a number of questions about essential research protocols (see Appendix D).

The CMNR found, however, that the two projects on basic and clinical nutritional neuroscience addressed high priority research questions and had the potential for yielding scientifically unique and important insights having far reaching applications. The CMNR encouraged frequent communication between the scientific teams on these projects. In contrast, the CMNR voiced serious reservations about the staffing and scientific adequacy of the menu modification project proposal. The Committee had similarly commented on the limitation on the research progress in the menu modification project in their earlier report (see Appendix C) and continued to find serious difficulties with the new proposal.

The CMNR further commented that the physical resources and overall staffing for the two neuroscience projects were well developed. The Committee suggested that periodic advice from nutrition research scientists, acting as consultants, who were trained in conducting human studies would further benefit the clinical neuroscience project.

In general, the CMNR was favorably impressed with the proposals from the neuroscience groups. The Committee indicated that through guidance from Drs. Ryan and Bray these research plans could be further strengthened through the addition of details to the research protocols that indicated clear understanding of the complexity and practicality of the methods to be employed. The CMNR, however, seriously questioned the relevance and appropriateness of the menu modification project.

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The full text of the CMNR letter reports, mentioned above, are included as Appendixes C and D.

Military Recommended Dietary Allowances

The U.S. Department of Defense (DoD) has utilized dietary recommendations with military personnel since 1919. During 1990 the Department of the Army began to discuss the need to revise the current version of the Military Recommended Dietary Allowances (MRDAs). At the June 28–30, 1990, meeting of the Committee on Military Nutrition Research (CMNR), the U.S. Army Research Institute of Environmental Medicine (USARIEM) requested that the CMNR discuss the MRDA review and revision at its subsequent meeting. The impetus for initiating a discussion of the adequacy of the current MRDA and the need for revision resulted from the publication of the 10th edition of the Recommended Dietary Allowances (RDA; for the general, healthy American population) by the Food and Nutrition Board (FNB) in late 1989.

BACKGROUND

A CMNR meeting on November 27–28, 1990 in Washington, D.C., was principally devoted to a discussion of the revision of the current MRDAs. COL (retired) David D. Schnakenberg, then Director, Army Systems Hazards, U.S. Army Medical Research and Development Command, provided a historical overview of military involvement with dietary recommendations. Early surveys of food consumption by soldiers resulted in establishment of the nutrient requirements for soldier training in 1919. These early requirements provided recommendations for consumption of protein, fat, and carbohydrate as a percentage of daily calories (12.5%, 25%, and 62.5%, respectively).

During the Second World War the focus on nutrient recommendations centered on optimal nutrition, not minimal requirements. Because of the emphasis on military nutrition, the FNB was established in 1940 under the auspices of the National Research Council, National Academy of Sciences, and began to prepare and publish RDAs for Americans. In 1947, the Department of the Army implemented military regulation AR 40-250, providing specified minimum nutrient intake levels as the dietary standard for garrison and field rations. The MRDA under AR 40-250 (now AR 40-25; the first tri-service regulation) has been revised numerous times through 1985, with revisions resulting from expanding scientific evidence on diet and health and from information provided in revisions of the RDA. Current policy covers not only MRDA for macronutrients and micronutrients, but also clarifies the use of the MRDA in menu planning, dietary evaluation of populations, nutrition education and research, and food research and development.

COL Schnackenberg's presentation was followed by additional presentations on the feasibility of attaining governmentally-established dietary recommendations and the process of establishing RDAs.

The Committee then began an in-depth discussion with representatives from DoD agencies about their respective concerns related to the revision of the MRDA. Overall, their concerns focused on the need for balance and control of macronutrient intake (i.e., protein, fat, and carbohydrate) and reduction in total fat, cholesterol, and sodium. Additional issues focused on the promotion of lifelong health, the palatability and acceptability of garrison meals, and the preference of military personnel for eggs and high-protein diets.

With the concurrent experience during Operation Desert Shield in Saudi Arabia, there was considerable discussion over the MRDA for sodium and the need for increased daily intake of sodium and fluid in hot environments related to military performance. Several DoD agencies could not support a single value for sodium intake that would cover both normal intake and intake under extreme environments.

The CMNR concluded its meeting with a discussion centering on the discrepancies between the RDAs and the MRDAs and proposals to accept the 10th edition of the RDAs as the MRDAs. However, concerns over protein, sodium, fat, and cholesterol were of importance in promoting health and performance in military personnel. Since the Army was in the process of drafting a revised MRDA, the CMNR deferred further discussion and formulation of recommendations until asked to comment on the revision.

REVISED RECOMMENDATIONS

In August, 1993 COL (now retired) Karen E. Fridlund, Chief, of the Dietitian Section, Department of the Army, Office of the Surgeon General, sent a letter to Bernadette Marriott, FNB Program Director for the CMNR, requesting that the Committee review and make comments on a recent draft of the MRDAs (AR 40-25, 1985). After discussion with COL Eldon W. Askew, Grant Officer Representative of the Army for the CMNR program, it was decided that the Committee would devote part of their executive session following a workshop in November, 1993 to review and comment on the MRDAs (AR 40-25, revised draft).

Prior to the November meeting, Bernadette Marriott, Program Director for the FNB for the CMNR, reviewed the original and revised drafts and developed a detailed comparative document to assist the Committee is their review process. On November 5, 1993 a sub-committee of the CMNR reviewed the comparison document and the original and draft revisions in detail. The Committee on Military Nutrition Research's role was to evaluate, comment upon and make specific recommendations regarding changes in the MRDAs designed to reflect changes where appropriate, in the latest version of the Recommended Dietary Allowances (RDAs), published by the Food and Nutrition Board (NRC, 1989b) and other relevant national policy statements on nutrition and health such as the *Surgeon General's Report on Nutrition and Health* (DHHS, 1988) and the *Diet and Health* report (NRC, 1989a). The CMNR understood fully that the responsibility for the final decisions in program remains with the Army.

The subcommittee found a number of aspects of the revised draft confusing and discussed their findings with the full Committee. The CMNR concluded that the confusion generated by the present draft could most likely be alleviated through expansion of several sections and the addition of explanatory footnotes and text. The Committee verbally conveyed their request for additional materials to COL Fridlund and deferred further discussion and formulation of recommendations until receipt of additional material or a second revised draft.

In late January, 1994 the CMNR received another revision of the MRDAs (AR 40-25, 1985) for their consideration and recommendations. The Committee included discussion of this revision in their executive session after a workshop in February, 1994. A letter report with CMNR recommendations is under preparation for submission to the U.S. Army Medical Research, Development, Acquisition, and Logistics Command (Provisional)

[USAMRDALC (PROV)] and Department of the Army, Office of the Surgeon General in late 1994 or early 1995.

Project Review of the Nutritional Intervention Study of the Ranger Training Class, 11/92 (Ranger II)

At the request of the U.S. Army Research Institute of Environmental Medicine (USARIEM), the Committee on Military Nutrition Research met in Washington, D.C. on March 15–17, 1993 to assist the Army in reviewing and evaluating the results of a nutritional intervention project conducted during the training program for the U.S. Army Ranger Class of November, 1992 (Ranger II). This activity was a followup to the Committee's review and evaluation of the results of the Army's study of the Ranger Training Class of November, 1991 (Ranger I) (IOM, 1992). The CMNR was asked to review the results of this nutritional intervention study conducted by USARIEM, answer five specific questions, evaluate the nutritional health and well-being of Ranger trainees, and make recommendations for future research. For this project, the Committee invited a special consultant to increase its expertise in the areas of energy metabolism and clinical medicine.

The Ranger Nutritional Intervention Study evaluated the health and performance of Ranger trainees under conditions of exposure to caloric and sleep deprivation with intensive physical activity. The Committee's three-day meeting culminated in the production of the report, *Review of the Results of Nutritional Intervention, Ranger Training Class 11/92 (Ranger II)* (Marriott, 1993). On the first day, the Committee heard presentations on the research results of the Ranger study. It met in executive sessions on days two and three to review the research results and develop its recommendations.

CONCLUSIONS

The Committee reviewed the Ranger assessment data provided by the Army scientists and the material covered during the oral presentations. A summary of the CMNR responses to the five questions posed by USARIEM are provided here.

1. Was the nutrition intervention (increasing energy provision by 10-15 percent) effective in decreasing medical risk?

There were several variations in the Ranger II study compared to Ranger I, but the significant intervention variable was the increase of approximately 15 percent in calories, along with additional protein. This change in intake appeared to reduce the severity of the weight loss of the groups and reduced the extremes of weight loss seen in the Ranger I study. A slightly reduced stress on immune function was also noted.

2. Should an even greater increase in energy intake be recommended (assuming it is consistent with Ranger training goals)?

Overall, the caloric supplement appeared compatible with Ranger goals. However, the value of additional increases in energy intake requires further study.

3. Should any specific supplementation of vitamins, minerals, or protein be considered?

No. Except for zinc, the data do not suggest any problems with regard to vitamin or mineral nutriture. (It was a rare, unusual, and unexplained finding that average plasma zinc concentrations were elevated in the trainees.) The more hypocaloric the state of the individual, the more protein will be required to minimize negative nitrogen balance.

4. Are the immunological changes noted related to the plane of nutrition during Ranger training or to other (e.g., sleep deprivation) stressors?

Some are clearly caused by the decreased plane of nutrition. Other concomitant stressors (e.g., loss of sleep and minor infections) could also contribute to the observed immune system derangements.

5. Are the decrements in cognitive function a cause for concern?

On the basis of data collected during a single study, it is premature to draw definitive conclusions. Answering this question requires full consideration of the nature of activities in which the trainees are engaged.

AREAS FOR FURTHER RESEARCH

The Committee divided recommendations for further research into three components: general research issues, questions that can be answered through further analyses of the existing data, and questions that can be answered by additional studies. Among the recommendations are the following:

General The Ranger studies offer the opportunity to collect invaluable information that is of health benefit to both the Army and the civilian population. Continue research with the Ranger Training Classes, particularly under varying environmental conditions. Refine the data analyses so that consideration of data on an individual subject basis is emphasized.

Additional analyses of the Ranger I and II data Investigate adequacy of protein intake, particularly during field training exercises. Determine possible correlations between initial body composition and the outcome physiological variables measured in the studies. Evaluate the composition of the weight regained and the length of time to restore lean body mass following the training program. Determine the cause of the hyperzincemia noted during the training.

Future studies Conduct a future study of U.S. Ranger Training that begins in winter. Develop a protocol to more completely assess recovery from Ranger Training. After training, continue studying a small number of people with the most weight loss; perhaps this project could be conducted in a metabolic unit and include muscle biopsies as well as indirect calorimetry to gain additional data during the recovery phase. Conduct additional immunological studies in the recovery stage. Include, in a future followup study, additional increments of calorie intake and/or sleep to evaluate the degree of the intensity of training necessary to achieve the desired outcome. Establish a procedure for evaluating individual participants longitudinally.

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The full conclusions and recommendations from this report are included in Appendix G.

Military Nutrition Research in Historical Perspective

COL Eldon W. Askew, Grant Officer Representative for the Army for the FNB's Committee on Military Nutrition Research (CMNR) program, in May, 1993 requested the assistance of the CMNR in documenting the contributions of the U.S. Army Medical Department to national nutrition knowledge and progress over the past century. This request was prompted by an initiative suggested by representatives of the American Institute of Nutrition (AIN) to develop a series of symposia and publications on the history of nutrition research. The CMNR was more specifically tasked to provide the structure for a brief meeting of military and academic scientists with a subcommittee of the CMNR to evaluate the concept of developing a symposium and publication on military nutrition history.

A small planning group consisting of Gilbert Leveille, John Vanderveen, Robert Nesheim (chair), and Bernadette Marriott (FNB Program Director) from the CMNR, COL (retired) David Schnakenberg from the USAMRDALC(PROV), and John Canham met in June, 1993. COL Eldon W. Askew, Elsworth Buskirk, and Allan Forbes had participated in correspondence prior to the meeting but were unable to attend. The task of the group was to list in sequential manner the research of the U.S. Army Medical Department that had been recognized for its contributions to nutrition knowledge not only for the military but also for the nation in general. John Vanderveen provided extensive bibliographies of military nutrition and health publications for staff review prior to the meeting. During the meeting the group reviewed the literature, and discussed their own collective experiences with various military medical laboratories throughout the country over the years. A draft chronology of events and research findings was prepared.

CONCLUSIONS AND RECOMMENDATIONS

The group concluded that the contributions of military medical research to national nutrition in terms of landmark publications, highly recognized scientists, and specific contributions to general nutrition knowledge of national significance was extensive. The development of a chronology of publishable quality and a symposium format would require extensive additional research, financial support and a commitment of time by individuals in preparing the symposium and its publications. It was decided that the CMNR would continue to pursue with the AIN the possibility of a symposium in the late 1990s.

Can Food Components Be Used to Enhance Soldier Performance?

Maximizing soldier performance, an important goal of all the military services, has been largely based on improving the training of personnel and the equipment they use and carry, and by improving military doctrine. However, today's soldiers face increasing demands, both physically in the loads they must carry and mentally in the cognitive abilities required to use the more sophisticated weaponry; both sets of factors place additional burdens on their nutritional needs. Military personnel in combat settings endure highly unpredictable timing and types of stresses as well as situations that require continuing vigilance for hours or days. Soldiers who consume the standard military rations are presumed to be in a state of good nutrition, especially given the liberal Military Recommended Dietary Allowances (MRDAs) (AR 40-25, 1985). But might special rations containing greater amounts of particular nutrients or other food components enhance performance—by improving performance above baseline levels or avoiding a reduction in performance during stress (such as experienced in battle situations) or both?

Substances that may optimize physical performance are often referred to as ergogenic aids. They can be aggregated into five categories: (1) mechanical, (2) psychological, (3) physiological, (4) pharmacological, and (5) nutritional. Foods and food components as ergogenic aids fall into the latter two categories. They may exert their actions by (1) acting as central or peripheral stimulants, (2) increasing the storage or availability of limiting substrates, (3) acting as a supplemental fuel source, (4) reducing or neutralizing metabolic by-products, and (5) enhancing recovery.

The CMNR was asked to assist a collaborative developmental program between scientists at the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Natick Research, Development and Engineering Center (NRDEC) by evaluating the performance-enhancing capabilities of food components—specifically tyrosine, other amino acids, complex carbohydrates, caffeine, carnitine, choline, and long-chain fatty acids. The Committee was asked to indicate which if any of these food components offered the most promise for future research that could lead to the development of prototype ration components for testing in laboratory and controlled field settings. In addition, it was asked to address six general questions dealing with enhancement of performance, summarized as follows:

- Is enhancement of physical and mental performance in normal, healthy, young soldiers by diet or supplements a potentially fruitful approach?
- With current scientific knowledge, is it possible to achieve a 10–15 percent enhancement of soldier performance in certain combat situations through the use of rations and/or nutrients?
- Which food components are the best candidates to enhance military physical and mental performance?
- What is the best way for soldiers to be supplemented—through fortified foods, special foods or beverages, or "vitamin pills?"
- Are there ethical issues that need to be considered with this type of research?
- What regulatory issues must be considered with the types of food components being evaluated by the Army?

There is a large volume of scientific literature on the topic of performance enhancement, but it is of diverse quality. The Committee reviewed the state of knowledge in this disparate area through convening a workshop that was held at the National Academy of Sciences in Washington D.C. on November 16–17, 1992. Prior to the workshop the CMNR asked the Army to develop several scenarios that illustrated the hypothetical application of food components in rations. The workshop included invited presentations from individuals familiar with or having expertise in cognition, endocrinology, exercise physiology, food science and engineering, immunology, metabolism, neuropsychology, nutrition, nutritional biochemistry, performance psychology, and sports medicine.

The Committee's report, *Food Components to Enhance Performance* (Marriott, 1994), provides responses to the six questions the CMNR was asked to address and includes recommendations for future research. The report also includes the 21 invited papers presented at the workshop. The Committee formulated its conclusions and recommendations on the basis of the workshop presentations and subsequent discussions and by its deliberations in executive session.

CONCLUSIONS AND RECOMMENDATIONS

The Committee recommended that the military ensure that troops are fed and hydrated adequately prior to military operations. The CMNR stated that prior to deployment, troops are presumably in good physical condition and have been consuming adequate rations to meet their nutrient needs; therefore, vitamin and mineral supplements are unlikely to improve performance. Stimulants such as caffeine given during continuous operations may help to overcome the effects of physical and mental fatigue. However, the Committee believes that the Army Science and Technology Objective (STO) (Army Science Board, 1991) of a 10–15 percent enhancement in performance of its well-fed, physically-fit soldiers by fiscal year 1998 can be obtained through consumption of specific rations or nutrients is overly optimistic. The CMNR believes there might be opportunities to meet this objective only if enhanced performance is defined as preventing or restoring all or part of the decrease in performance that is usually encountered overextended field operations (since troops in such circumstances tend to reduce food intake, lose weight, and sometimes dehydrate).

The Committee concluded that sufficient evidence exists to conclude that carbohydrates, caffeine, tyrosine, and choline have the potential to sustain performance in militarily relevant situations. The Committee stated that carnitine and structured lipids were food components of theoretical importance but currently offer a low probability of demonstrating improved performance under anticipated conditions in military operations. The following represents a summary of the CMNR recommendations:

Carbohydrates This macronutrient is a fuel source for extended physical activity. Carbohydrate supplements are most useful for persons engaged in continuous, moderate physical activity over at least 1.5 to 2 hours, as it can extend the time to exhaustion. Carbohydrates may also affect behaviors such as mood, performance, and satiety. Research in evaluating the benefits of supplemental carbohydrates on performance should include evaluations of their effects on motivation to operate under stressful conditions such as combat and on coping under such conditions. Laboratory studies indicate that consumption of supplements with a high ratio of carbohydrate to protein increase fatigue. Based on these results, the CMNR suggests that research on sleep promotion could address the macronutrient ratios in supplements.

Caffeine Caffeine affects the central nervous system by blocking adenosine receptors, which tend to delay sleep and reduce the deterioration of performance associated with fatigue and boredom. The principal side effects include nervousness, jitteryness, and decreased sleepiness which may persist for several hours. Caffeine should definitely be considered in developing performance-enhancing rations or ration components. Doses of 300–600 mg/70-kg person will achieve the desired stimulus in those nonhabituated to caffeine. Research is required to determine the effective dosage for those with higher habitual caffeine intakes.

Tyrosine Under highly stressful conditions, this amino acid, the precursor of dopamine, norepinephrine, and epinephrine, may be the limiting substrate for the synthesis of these neurotransmitters. Tyrosine supplements have reduced the adverse effects of hypoxia, cold, body negative pressure, and psychological stress both in humans and animals. Additional research is needed on tyrosine to demonstrate the generalizability of its effects across a wider range of stressors, establish a dose-response function for its beneficial effects, determine whether it is helpful in chronic stress paradigms, determine the safety of its administration, assess the risks and benefits of acute versus chronic administration, and determine the most appropriate method for providing it as a supplement.

Choline Choline has a variety of functions in the body, but its best-known function is as a component of the neurotransmitter acetylcholine. There is evidence that diets low in choline reduce muscle performance. Choline supplements enhance memory in humans; in animals (particularly aged ones), choline supplements enhance memory as well as reaction time. Choline is a normal constituent of many foods and is safe at high levels of intake, so the CMNR recommends that it is worth evaluating to determine whether it may enhance the physical or cognitive performance of soldiers functioning in stressful environments.

Given that the cognitive, emotional, and physical aspects of performance is of crucial importance to all service branches, the Committee further recommended that the military establish an interservice committee to coordinate and facilitate research and development activities in this area. Some of the necessary animal research might be accomplished through the Army-funded neuroscience research at the Pennington Biomedical Research Center in Baton Rouge, Louisiana, to complement and support the human studies at USARIEM.

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The full conclusions and recommendations from this report are included in Appendix I.

Underconsumption of Military Field Rations: What Strategies Can Be Employed to Overcome this Problem?

Since 1982 the Army has field tested and the CMNR has reviewed a number of studies conducted by the Army of soldier intake of operational rations in various environmental conditions. Across these studies the Army scientific staff noted recurring underconsumption of the study ration in that soldiers did not consume sufficient calories to meet energy expenditure and consequently lost body weight. The caloric deficit has consistently been in the range of 700–1,000 kcal per day and thus raises concern about the influence of such a deficit on physical and cognitive performance, particularly over a period of extended use. Other studies involving special purpose operational rations supplying limited energy (1,500–2,000 kcal), but based on similar design of the Meal, Ready-To-Eat (MRE), were usually fully consumed and weight losses were experienced as would be predicted by the limited calories in the rations. Additionally, anecdotal reports from Operation Desert Storm indicated that some units may have used MREs as their sole source of food for 50 to 60 days—far longer than the original intent when the MRE was initially field tested.

Surprisingly, hedonic ratings of the ration items in field studies have been usually quite positive, in spite of the actual intakes. Successive modifications of the MRE have produced small improvements in total consumption but have not affected the major caloric deficit.

The Committee on Military Nutrition Research (CMNR) of the Food and Nutrition Board (FNB) was asked to assist a collaborative program between scientists in the Division of Military Nutrition, U.S. Army Research Institute of Environmental Medicine (USARIEM), and the U.S. Army Natick Research, Development and Engineering Center (NRDEC), to strategize on how to overcome underconsumption of military operational rations. An underlying question to be reviewed was whether this was an expected and perhaps preventive situation in combat settings. The CMNR was requested to hold a workshop to review the relevant literature, hear the most current research findings from within the Army related to these issues, and consider assessments of this issue from experts in related fields. The workshop was developed to thus focus on the various factors that may contribute to the reduced intake of operational rations, the potential effect on soldier performance, and suggest steps that may be taken to overcome the problem.

A small planning group was given the task of identifying the pertinent topics and the participants. This task force, comprised of representatives from USARIEM, Natick Laboratories, and the CMNR, met at USARIEM on April 30, 1993, to plan the workshop. The task force developed five questions to be addressed at the workshop:

1. Why do soldiers underconsume (not meet caloric expenditure in field operations?)

2. What factors influence underconsumption in field operations? Identify the relative importance of:

- Rations
- Environment
- Eating situation
- The individual

3. At what level of underconsumption is there a negative impact on physical or cognitive performance? What can be done to overcome this degradation?

4. What steps are suggested to enhance ration consumption within the environment of military operations? Similarly, what can be done to overcome deficits in food intake?

5. What further research needs to be done in these areas?

The CMNR recognized that underconsumption of field rations is a complex issue that is related to an individualized response to the multiple stressors of a field training or operational setting. In the planning session with scientists from USARIEM and NRDEC, committee members voiced the need to hear more specific information about (a) Army field feeding logistics; (b) new developments in operational rations; (c) an overview of Army research on food intake patterns and factors affecting food intake; (d) recent Army research results on the impact of lowered caloric intake on performance; and (e) expert reviews of physiological, psychological and social factors that influence eating. This information was incorporated into presentations from Army scientists and staff at the workshop.

The workshop was held November 3–4, 1993 at Natick, Massachusetts. This workshop included presentations from military and non-military scientists with expertise in food engineering, food marketing strategies, food science, nutrition, nutritional biochemistry, physiology, psychology, and social factors. A panel discussion was held at the end of the workshop to summarize the findings and discuss potential strategies to increase ration intake. The four invited panelists brought additional expertise in food development, complex data analysis, nutrition education, and ingestive behavior. The invited speakers were chosen for their specific expertise in the areas related to the meeting topic and were requested to present in-depth reviews of their area of expertise as it directly applied to the five questions and to include their own recommendations on the issues. Speakers subsequently submitted written versions of their presentations. Committee members later reviewed the workshop presentations and drew on their own expertise and the scientific literature to develop their summary, conclusions, and recommendations. The summary and recommendations of the CMNR will be reviewed by the FNB and an anonymous panel of peers according to National Research Council policy.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of the Committee on Military Nutrition Research will be submitted to the U.S. Army Medical Research, Development, Acquisition, and Logistics Command (Provisional) [USAMR-DALC (PROV)] as part of the workshop report, *Not Eating Enough, Strategies to Overcome Underconsumption of Operational Rations* in early 1995. The proceedings of this workshop will be published and disseminated using the workshop format in the CMNR series style. This study has thus originated from concern within the military about the consistency of the deficit in caloric intake and whether such a decrement could lead to important reductions in physical and/or cognitive performance of troops in military operations. The report will focus on the various factors that may contribute to the reduced intake of operational rations, the potential effect on soldier performance, and suggest steps that may be taken to overcome the problem.

Use of Carbohydrate-Electrolyte Solutions for Fluid Replacement

Military personnel must often perform heavy physical activity in very hot environments during training or under combat conditions. The high sweat rates can lead to dehydration, resulting in performance decrements through elevated heart rates, reduced sweat rates, and elevated body temperature and threats to health. Glucose-electrolyte solutions have been found useful in rehydration and in preventing dehydration. Carbohydrate is essential as it facilitates sodium and water absorption. Other ions may or may not be needed, depending on losses in sweat or from the gastrointestinal tract. Advances in exercise physiology demonstrate the value of carbohydrate solutions in providing energy for muscular activity in vigorous endurance events that last at least one hour. A carbohydrate-electrolyte beverage, therefore, could be useful in providing glucose to sustain muscular activity in troops involved in heavy physical activity for long periods. The sodium in these beverages might also be especially important since garrison or field rations may be reduced in sodium to meet prudent dietary guidelines.

In February 1989, the Committee on Military Nutrition Research held a workshop on the subject of fluid replacement and military performance at the request of the U.S. Army Medical Research and Development Command. The Committee was asked specifically to address twelve questions on the potential utility of fluid replacement, including carbohydrate-electrolyte beverages, in enhancing sustained military performance in military operations. The Committee's report, *Fluid Replacement and Heat Stress*, (Marriott and

Rosemont, 1991) responds to these questions and makes recommendations for future research. Fifteen papers were presented at the workshop, ranging in subject from the body's accommodation to heat and exercise to palatability issues in enhancing fluid intake. The committee report includes these invited papers. This summary is prepared for the third printing of *Fluid Replacement and Heat Stress* (Marriott, 1994), a report that continues to be popular and for which there is a steady demand for copies.

CONCLUSIONS AND RECOMMENDATIONS

At a decrease of 3 percent in body weight due to dehydration, the capacity to perform physical work decreases substantially. Research reported at the workshop made evident that a fluid replacement solution may play an important role in preventing fluid, electrolyte, and glycogen depletion, thereby maintaining or improving a soldier's performance. Depending on the physical demands of the military activity and prevailing environmental conditions, the composition of the replacement fluid might vary.

The Committee recommended that the Surgeon General of the Army evaluate the use of carbohydrate-electrolyte fluid replacement products as an aid to maintaining proper hydration of soldiers and assess their effectiveness in maintaining and enhancing the physical and cognitive performance of the soldiers during training activities and field operations. Specifically, the Committee recommended that fluid-replacement products provide approximately 20 to 30 meq of sodium per liter, 2 to 5 meq of potassium per liter, and chloride as the only anion. Carbohydrate content was recommended in a concentration of 5 to 10 percent as glucose, sucrose, malto-dextrin, or other complex carbohydrate.

AREAS FOR FUTURE RESEARCH

The workshop provided investigators and product formulators with guidance in the development and testing of carbohydrate-electrolyte fluid replacement products for use by the military. Continued research is needed on energy, electrolyte, and fluid requirements in different environmental and operational conditions that require different types of physical activity. More studies are also needed to provide a better understanding of the factors affecting liver and muscle metabolism and injury during heat stress and those important in preventing muscle injury during heat stress and enhancing muscle recovery. The Committee also recommended research into manipulating the flavor and color of fluid replacement products to promote fluid intake, and to the potential benefits of adding additional magnesium, bicarbonate, and phosphate to compensate for gastrointestinal losses due to diarrhea or other disturbances.

* * * * *

The full conclusions and recommendations from this report are included in Appendix H.

Nutritional Requirements for Work in Cold and High Altitude Environments

The Committee on Military Nutrition Research (CMNR) was asked by the Division of Military Nutrition, U.S. Army Institute of Environmental Medicine (USARIEM), to review current research pertaining to nutrient requirements for working in cold and high altitude environments and to comment on how this information may be applied to military nutrient standards and military rations. The Committee was thus tasked with providing a thorough review of the literature in this area and interpreting these diverse data in terms of military applications. In addition to a focus on specific nutrient needs in cold environments, the Committee was asked to include consideration of factors that might change food intake patterns and therefore overall energy intake. The Army has conducted extensive research in this area and the CMNR has previously discussed both specific ration items (Ration, Cold Weather [RCW]) and Alaska -based cold weather experimental studies that compared soldier intake and performance between several versions of the Meal, Ready-to-Eat (MRE) and the RCW (Marriott, and Earl, 1992). This project also parallelled and earlier CMNR study of the nutrient requirements for hot environments (Marriott, 1993; see page XX and Appendix G).

The principal questions that the CMNR was asked to address were:

1. Aside from increased energy demands, do cold or high altitude environments elicit an increased demand or requirement for specific nutrients?

2. Can performance be enhanced in cold or high altitude environments by the provision of increased amounts of specific nutrients?

To assist the CMNR in developing a response to these questions, a workshop was convened on January 31-February 2, 1994 in Washington, D.C., that included presentations from individuals familiar with or having expertise in digestive physiology, energetics, macronutrients, vitamins, minerals, appetite, psychology, exercise physiology, and high altitude physiology. The titles of the presented papers are listed below:

- Scenarios of Cold Exposure in Military Settings
  William D. Strauss
  COL Russell W. Schumacher, Jr.
- How the Army Feeds Soldiers in the Cold
  LTC Nancy King
  CW4 Thomas J. Lange
- The Physiology of Cold Exposure
  Andrew J. Young
- Central Nervous System Function, Sleep, and Cold Stress
  Robert S. Pozos
- The Influence of Cold Exposure on Body Fluid Balance
  Major Beau Freund
- Muscle Metabolism and Shivering During Cold Stress
  Ira Jacobs
- Macronutrient Requirements for Work in Cold Environments
  Peter J.H. Jones
- Cold Exposure, Appetite, and Energy Balance
  Jacques LeBlanc
- Influence of Cold and Altitude on Vitamin and Mineral Requirements
  Robert D. Reynolds
- Micronutrient Deficiency States and Thermoregulation in the Cold
  John L. Beard
- Drug-Induced Delay of Hypothermia
  Andre Vallerand
- Food and Ice
  Robert E. Feeney
- The Physiology of High Altitude Exposure
  Allen Cymerman
- The Effects of High Altitude on Physical Performance and Well-Being
  Robert B. Schoene
- Fluid Metabolism at High Altitude
  Inder S. Anand

- Effects of High Altitude on Basal Energy Requirement, Body Composition Maintenance and Fuel Source When Energy Intake is Adequate
  Gail E. Butterfield
- Energy and Macronutrient Requirements for Work at High Altitude
  Reed W. Hoyt
- Vitamin E and Antioxidants
  Irene Simon-Schnass
- Effects of Altitude on Cognitive Performance and Mood States
  Barbara Shukitt-Hale
- Environmental Stress Management by Adaptogens
  Kaushal Kishore Srivastava
- Food Components and other Treatments that may Enhance Mental Performance at High Altitude and in the Cold
  Harris Lieberman

A panel discussion was held at the end of the workshop to summarize the findings and discuss specific issues raised during the two-day workshop. The six invited panelists, Robert B. Schoene, Robert S. Pozos, Murray Hamlet, Bill Strauss, Irwin Taub, and COL Russell Schumacher, had either contributed presentations to the workshop or brought additional expertise in food development, cold physiology, high altitude research, and military operations at high altitude.

The invited speakers discussed their presentations with the Committee members at the workshop and submitted the content of their verbal presentations as written reports. The committee met in executive session after the workshop to discuss the issues raised and the information provided. The members of the committee will draw upon their expertise and the scientific literature to develop a summary, conclusions, and recommendations based on this workshop. The CMNR is currently in the process of completing this report for submission to the U.S. Army Medical Research, Development, Acquisition, and Logistics Command (Provisional) [USAMRDALC (PROV)]. The completed report will also include the written papers by invited speakers and will be submitted in early spring, 1995 in the CMNR workshop report series format.

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Appendixes

A. Meetings of the Committee on Military Nutrition Research, April 1, 1992–November 30, 1994

B. Biographical Sketches of Members of the Committee on Military Nutrition Research, April 1, 1992–November 30,1994

C. Letter Report: Research Progress Review of the Pennington Biomedical Research Center, submitted May 1992

D. Letter Report: Committee on Military Nutrition Research Review of Three Research Proposals from the Pennington Biomedical Research Center, submitted December 1992

E. Conclusions and Recommendations from the Workshop Report: *Body Composition and Physical Performance*, submitted August 1992

F. Conclusions and Recommendations from the Workshop Report: *Nutritional Needs in Hot Environments,* submitted March 1993

G. Conclusions and Recommendations from the Brief Report: *Review of the Results of Nutritional Intervention, Ranger Training Class 11/92 (Ranger II),* submitted June 1993

H. Summary and Recommendations from the Workshop Report: *Fluid Replacement and Heat Stress, third printing,* submitted January 1994

I. Conclusions and Recommendations from the Workshop Report: *Food Components to Enhance Performance*, submitted May 1994

Appendix A

Meetings of the Committee on Military Nutrition Research

April 1, 1992–November 30, 1994

Meetings of The Committee on Military Nutrition Research April 1, 1992–November 30, 1994[1]

Dates	Topics	Location
May 11, 1992	Workshop Planning Meeting (Subcommittee): Potential Food Components to Enhance Performance	Washington, D.C.
June 2–3, 1992	Research Review Meeting (Subcommittee): Review of Army Research Projects at the Pennington Biomedical Research Center	Baton Rouge, LA
July 20–21, 1992	CMNR Report Working Session (Subcommittee): Nutritional Needs in Hot Environments	Washington, D.C.
November 16–17, 1992	Workshop (Full committee): Evaluation of Potential Performance Enhancing Food Components	Washington, D.C.
March 15–17, 1992	Research Review Meeting (Full Committee): Review of the Results of Nutritional Intervention, Ranger Training Class 11/92 (Ranger II)	Washington, D.C.

April 30, 1993	Workshop Planning Meeting (Subcommittee): Strategies to Overcome Underconsumption of Field Rations	Natick, MA
June 4, 1993	CMNR Working Session (Subcommittee): Military Nutrition History and Food Components to Enhance Performance	Washington, D.C.
August 23, 1993	Workshop Planning Meeting (Subcommittee): Nutrient Requirements in Cold and High Altitude Environments	Natick, MA.
November 3–5, 1993	Workshop (Full committee): Strategies to Overcome Underconsumption of Field Rations	Natick, MA
January 31– February 2, 1994	Workshop (Full committee): Nutrient Requirements for Work in Cold and High Altitude Environments	Washington, D.C.

[1] Listed are all full committee meetings, workshops, planning meetings, sub-committee meetings, and larger working sessions. Meetings between the chair and staff, and small working sessions are not included.

Appendix B

Biographical Sketches of Members of the Committee on Military Nutrition Research

April 1, 1992–November 30, 1994

Biographical Sketches of Members of the Committee on Military Nutrition Research[1]

ROBERT O. NESHEIM (*Chair*) was Vice President of Research and Development and later Science and Technology for the Quaker Oats Company. He retired in 1983 and was Vice President of Science and Technology and President of the Advanced HealthCare Division of Avadyne, Inc. before his retirement in 1992. During World War II, he served as a Captain in the U.S. Army. Dr. Nesheim has served on the Food and Nutrition Board, chairing the Committee on Food Consumption Patterns and serving as a member of several other committees. He also was active in the Biosciences Information Service as its Board Chairman, American Medical Association, American Institute of Nutrition, Institute of Food Technologists, and *Food Reviews International* editorial board. He is a fellow of the American Institute of Nutrition and American Association for the Advancement of Science and a member of several professional organizations. Dr. Nesheim received a B.S. in Agriculture, M.S. in Animal Science, and Ph.D. in Nutrition and Animal Science from the University of Illinois.

RICHARD L. ATKINSON is Professor of Internal Medicine, Department of Nutritional Science at the University of Wisconsin-Madison. He was the Associate Chief of Staff for Research and Development at the Veterans' Affairs Medical Center in Hampton, Virginia. Concurrently, Dr. Atkinson was Professor of Internal Medicine and Chief of the Division of Clinical Nutrition

[1]Unless footnoted, affiliations listed correspond to initial committee membership period.

at the Eastern Virginia Medical School in Norfolk, Virginia. He served 4 years in the military at Walter Reed Army Hospital in Washington, D.C. and the U.S. Army Hospital in Fort Campbell, Kentucky. Dr. Atkinson is an editorial board member for the *Journal of Nutrition*, a medical advisory board member for *Obesity Update*, and a contributing editor for *Nutrition Reviews*. He is a member of the American Association for the Advancement of Science, American Institute of Nutrition, and Endocrine Society; he is a fellow of the American College of Nutrition and American College of Physicians. Dr. Atkinson holds a B.A. from the Virginia Military Institute in Lexington and M.D. from the Medical College of Virginia in Richmond, where he served his internship. He then completed his residency at Harbor General Hospital in Torrance, California.

WILLIAM R. BEISEL is Adjunct Professor in the Department of Immunology and Infectious Diseases at the Johns Hopkins School of Hygiene and Public Health. He held several positions at the U.S. Army Medical Research Institute for Infectious Diseases at Fort Detrick, Maryland, including in turn, Chief of the Physical Sciences Division, Scientific Advisor, and Deputy for Science. He then became Special Assistant for Biotechnology to the Surgeon General. After serving in the U.S. military during the Korean War, Dr. Beisel was the Chief of Medicine at the U.S. Army Hospital in Ft. Leonard Wood, Missouri, before becoming the Chief of the Department of Metabolism at the Walter Reed Army Hospital. He was awarded a Commendation Ribbon, Bronze Star for the Korean War, Hoff Gold Medal at the Walter Reed Army Institute of Research, B. L. Cohen Award of the American Society for Microbiology, and Department of Army Decoration for Exceptional Civilian Service. He was named a diplomate of the American Board of Internal Medicine and a fellow of the American College of Physicians. In addition to his many professional memberships, Dr. Beisel is a *Clinical Nutrition* contributing editor and *Journal of Nutritional Immunology* editor. He received his A.B. from Muhlenberg College in Allentown, Pennsylvania, and M.D. from the Indiana University School of Medicine.

GAIL E. BUTTERFIELD is Director of Nutrition Studies at the Geriatric Research, Education, and Clinical Center of the Palo Alto Veterans Administration Medical Center in California. Concurrently, she is Lecturer in the Department of Medicine, Stanford University Medical School, and Visiting Assistant Professor in the Department of Human Biology, Stanford University. Her previous academic appointments were at the University of California-Berkeley. Dr. Butterfield belongs to the American Institute of Nutrition, American Dietetic Association, and American Physiological Society. As a fellow of the American College of Sports Medicine, she serves on the Position

Stands Committee and the editorial board for *Medicine and Science in Sports and Exercise*. She also was the Past President and Executive Director of the Southwest Chapter of that organization and an Ad Hoc Member for the Respiratory and Applied Physiology Study Section of the National Institutes of Health. Dr. Butterfield received her A.B. in Biological Sciences, M.A. in Anatomy, and M.S. and Ph.D. in Nutrition from the University of California-Berkeley.

JOHN D. FERNSTROM is Professor of Psychiatry, Pharmacology, and Behavioral Neuroscience at the University of Pittsburgh School of Medicine, and Director, Basic Neuroendocrinology Program at the Western Psychiatric Institute and Clinic. He received his S.B. in Biology and his Ph.D. in Nutritional Biochemistry from the Massachusetts Institute of Technology (M.I.T.). He was a Post-doctoral Fellow in Neuroendocrinology at the Roche Institute for Molecular Biology in Nutley, New Jersey. Before coming to the University of Pittsburgh, Dr. Fernstrom was an Assistant and then Associate Professor in the Department of Nutrition and Food Science at M.I.T. He has served on numerous governmental advisory committees. He presently is a member of the National Advisory Council of the Monell Chemical Senses Center and is chairman of the Neurosciences Section of the American Institute of Nutrition. He is a member of numerous professional societies, including the American Institute of Nutrition, the American Society for Clinical Nutrition, the American Physiological Society, the American Society for Pharmacology and Experimental Therapeutics, the American Society for Neurochemistry, the Society for Neuroscience, and the Endocrine Society. Among other awards, Dr. Fernstrom received the Mead-Johnson Award of the American Institute of Nutrition, a Research Scientist Award from the National Institute of Mental Health, a Wellcome Visiting Professorship in the Basic Medical Sciences, and an Alfred P. Sloan Fellowship in Neurochemistry. His current major research interest concerns the influence of the diet and drugs on the synthesis of neurotransmitters in the central and peripheral nervous systems.

JOEL A. GRINKER is Professor of Pediatrics and Communicable Diseases at the School of Public Health, University of Michigan-Ann Arbor. She is a member of the university's Center for Human Growth and Development and served as Director of the Program in Human Nutrition. She was Visiting Scientist at the USDA Human Nutrition Research Center on Aging at Tufts University in Boston and Visiting Associate Professor at the Lavaratoire de Neurophysiologie Sensorielle et Comportementale, College de France, Paris. Currently, she is a reviewer for the National Cancer Institute, National Institutes of Health, and National Science Foundation and for several professional journals. She serves on the editorial boards for *Appetite, Journal* *of Eating Disorders*, and *Psychosomatic Medicine*. She is a fellow of the American Psychological Association, American Association for the Advancement of Science, and New York Academy of Sciences and is a member of several professional societies. Dr. Grinker holds a B.A. in Psychology from Wellesley College in Massachusetts and Ph.D. in Experimental Social Psychology from New York University. At Rockefeller University, she was a Russell Sage Post-doctoral Fellow in the Laboratory of Human Behavior and Metabolism of Dr. Jules Hirsch and then Assistant and Associate Professor.

EDWARD S. HORTON is Chief of the Division of Endocrinology and Metabolism at Deaconess Hospital and Medical Director for the Joslin Diabetes Center in Boston. Formerly, he was Director of Endocrinology and Metabolism and then Chair of the Department of Medicine and Chief of the Medical Service at the University of Vermont College of Medicine in Burlington. He is a graduate of Harvard Medical School and received his training in Internal Medicine and Endocrinology and Metabolism at Duke University. Dr. Horton is the recipient of several awards and distinctions, including the Banting Medal for Distinguished Service awarded by the American Diabetes Association and the American Society for Clinical Nutrition's Robert H. Herman Award. He is Past President of the American Diabetes Association and of the American Society for Clinical Nutrition. He also served as the Associate Editor of *Diabetes Care* and as Chair of the National Diabetes Advisory Board. Dr. Horton's major research has involved studies of the regulation of energy expenditure in humans, the interrelationships between obesity and diabetes mellitus and the mechanisms of insulin resistance in skeletal muscle and adipose tissue. He is, particularly, interested in the effects of exercise and physical conditioning on insulin sensitivity and the regulation of glucose transport and metabolism in skeletal muscle.

G. RICHARD JANSEN is a Professor Emeritus in the Department of Food Science and Human Nutrition at Colorado State University, where he was head of the department from 1969–1990. He was a Research Fellow at the Merck Institute for Therapeutic Research and Senior Research Biochemist in the Electrochemical Department at E. I. DuPont de Nemours. Prior to his stint in private industry, he served in the U.S. Air Force. Dr. Jansen is a past member of the U.S. Department of Agriculture (USDA) Human Nutrition Board of Scientific Counselors and the *Journal of Nutrition, Nutrition Reports International*, and *Plant Foods for Human Nutrition* editorial boards. His research interests deal with protein energy relationships during lactation and new foods for LDCs based on low-cost extrusion cooking. He received the

Babcock-Hart Award of the Institute of Food Technologists and a Certificate of Merit from the USDA's Office of International Cooperation and Development for his work on low-cost extrusion cooking, and he is an IFT Fellow. He is a member of the American Institute of Nutrition, Institute of Food Technologists, and American Society for Biochemistry and Molecular Biology among others. Dr. Jansen holds a B.A. in Chemistry and Ph.D. in Biochemistry from Cornell University in Ithaca, New York.

ORVILLE A. LEVANDER is Research Leader for the U.S. Department of Agriculture (USDA) Vitamin and Mineral Nutrition Laboratory in Beltsville, Maryland. He was Research Chemist at the USDA's Human Nutrition Research Center, Resident Fellow in Biochemistry at Columbia University's College of Physicians and Surgeons, and Research Associate at Harvard University's School of Public Health. Dr. Levander served on the Food and Nutrition Board's Committee on the Dietary Allowances. He also served on the National Research Council's Committee on Animal Nutrition and Committee on the Biological Effects of Environmental Pollutants. He was a member of the U.S. National Committee for the International Union of Nutrition Scientists and temporary advisor to the World Health Organization's Environmental Health Criteria Document on Selenium. Dr. Levander was awarded the Osborne and Mendel Award for the American Institute of Nutrition. His society memberships include the American Institute of Nutrition, American Chemical Society, and American Society for Clinical Nutrition. Dr. Levander received his B.A. from Cornell University and his M.S. and Ph.D. in Biochemistry from the University of Wisconsin-Madison.

GILBERT A. LEVEILLE is Vice President for Research and Technical Services at the Nabisco Foods Group in East Hanover, New Jersey. His other industry experience was as the Director of Nutrition and Health Science for the General Foods Corporation. He was Chair and Professor of Food Science and Human Nutrition at Michigan State University, Professor of Nutritional Biochemistry at the University of Illinois-Urbana, and a Biochemist at the U.S. Army Medical Research and Nutrition Laboratory in Colorado. Dr. Leveille is a current member on the Committee on International Nutrition, a joint Food and Nutrition Board-Board on International Health project. He won a Research Award from the Poultry Science Association, the Mead Johnson Research Award from the American Institute of Nutrition, the Distinguished Faculty Award from Michigan State University, and the Carl R. Fellers Award from the Institute of Food Technologists. He is a member of the American Association for the Advancement of Science, American Institute of Nutrition (Past President), American Society for Clinical Nutrition, American Chemical Society, Institute of Food Technologists (Past President), and Sigma Xi. Dr.

Leveille received his B.V.A. from the University of Massachusetts and M.S. and Ph.D. in Nutrition and Biochemistry from Rutgers University, New Jersey.

JOHN MILNER is Professor and Head of the Nutrition Department at the Pennsylvania State University at University Park since 1989. He has a Ph.D. in Nutrition from Cornell University in Ithaca, New York. Dr. Milner has a broad background in both fundamental and applied nutrition. His own research deals with the role of the diet as a modifier of cancer risk.

JAMES G. PENLAND is a Research Psychologist at the Agriculture Research Services (ARS) Grand Forks Human Nutrition Research Center, U.S. Department of Agriculture (USDA), in Grand Forks, North Dakota. Concurrently, he is an Adjunct Professor and Instructor in the Department of Psychology at the University of North Dakota at Grand Forks. He serves on several USDA committees, including the "Just Say No" Anti-Drug Program for which he is the Regional Coordinator for the Eastern North Dakota Area. Dr. Penland is a member of the American Institute of Nutrition, American Psychological Association, American Statistical Association, Midwestern Psychological Association, North Dakota Academy of Science, and Sigma Xi. He is a reviewer for the *American Journal of Clinical Nutrition* and *Journal of Trace Elements and Experimental Medicine*; for the USDA, he is a CRIS project reviewer for the ARS and a technical consultant for the ARS Western Human Nutrition Research Center. Dr. Penland received a Ph.D. in Experimental Psychology and an M.A. in General-Experimental Psychology from the University of North Dakota and a B.A. in Psychology from the Metropolitan State College of Denver.

JOHN E. VANDERVEEN is the Director of the Food and Drug Administration's (FDA) Office of Plant and Dairy Foods and Beverages in Washington, D.C. His previous position at the FDA was Director of the Division of Nutrition, at the Center for Food Safety and Applied Nutrition. He also served in various capacities at the United States Air Force School of Aerospace Medicine at Brooks Air Force Base, Texas. He has received accolades for service from the FDA and the USAF. Dr. Vanderveen is a member of the American Society for Clinical Nutrition, American Institute of Nutrition, Aerospace Medical Association, American Dairy Science Association, Institute of Food Technologists, and American Chemical Society. In the past, he was the Treasurer of the American Society of Clinical Nutrition and a member of the Institute of Food Technology, National Academy of Science Advisory Committee. Dr. Vanderveen holds a B.S. in Agriculture from Rutgers University, New Jersey and a Ph.D. in Chemistry from the University of New Hampshire.

ALLISON A. YATES is Dean of the College of Health and Human Sciences at the University of Southern Mississippi and Professor of Foods and Nutrition. She is currently on leave as Dean to serve as Director of the Food and Nutrition Board of the Institute of Medicine in Washington, D.C. She has a Ph.D. in Nutrition from the University of California at Berkeley, and an M.S. in Public Health from UCLA, and is a registered dietitian. Her areas of expertise are in food habits, diet composition, and protein and energy interrelationships.

JOHANNA T. DWYER ***(FNB Liaison)*** is the Director of the Frances Stern Nutrition Center at New England Medical Center, Professor of Medicine and Community Health at the Tufts University School of Medicine, and Professor of Nutrition at Tufts University School of Nutrition in Boston. She is also Senior Scientist at the Jean Mayer/USDA Human Nutrition Research Center on Aging at Tufts. Dr. Dwyer is the author or coauthor of more than 80 research articles and 175 review articles published in scientific journals. Her work centers on life-cycle related concerns such as the prevention of diet-related disease in children and adolescents and maximization of quality of life and health in the elderly. She also has a longstanding interest in vegetarian and other alternative lifestyles.

Dr. Dwyer is the President of the American Institute of Nutrition, past Secretary of the American Society for Clinical Nutrition, and past President and current Fellow of the Society for Nutrition Education. She served on the Program Development Board of the American Public Health Association from 1989 to 1992 and is a member of the Food and Nutrition Board of the National Academy of Sciences, the Technical Advisory Committee of the Nutrition Screening Initiative, and the Board of Advisors for the American Institute of Wine and Food. As the Robert Wood Johnson Health Policy Fellow (1980–1981), she served on the personal staffs of Senator Richard Lugar (R-Indiana) and the Hon. Barbara Mikulski (D-Maryland).

Dr. Dwyer has received numerous honors and awards for her work in the field of nutrition, including the J. Harvey Wiley Award from the Society for Nutrition Education. She was invited to give the Lenna Frances Cooper Lecture at the annual meeting of the American Dietetic Association in 1990. Dr. Dwyer is currently on the Editorial Advisory Board for *Clinics in Applied Nutrition* and is a Contributing Editor for *Nutrition Reviews* as well as a reviewer for the *Journal of the American Dietetic Association* and the *American Journal of Public Health.* She received her D.Sc. and M.Sc. from the Harvard School of Public Health, an M.S. from the University of Wisconsin, and completed her undergraduate degree with distinction from Cornell University.

BERNADETTE M. MARRIOTT (***FNB Staff, Program Director***) is Program Director for the Committee on Military Nutrition Research and Deputy Director, Food and Nutrition Board, Institute of Medicine. She has a Ph.D. in Psychology from the University of Aberdeen, Scotland, and B.Sc. in Biochemistry/Immunology and post doctoral laboratory training in comparative medicine and trace mineral nutrition. She serves on the Scientific Advisory board for the Diagon Corporation and the American Health Foundation. She serves as scientific reviewer for the National Institues of Health, National Science Foundation and National Geographic. Prior to joining the Institute of Medicine staff, she held university and medical school faculty positions at Johns Hopkins University and the University of Puerto Rico Schools of Medicine, and Goucher College. Her areas of research interest include bioenergetic modeling, trace mineral nutrition, and ingestive behavior in human and nonhuman primates.

Appendix C

Letter Report: Research Progress Review of the Pennington Biomedical Research Center

Submitted May 1992

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May 15, 1992

Major General Richard T. Travis
Commanding General
U.S. Army Medical Research and Development Command
Fort Detrick
Frederick, MD 21702-5012

Dear General Travis:

At the specific request of the COL Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM) who is Grant Officer Representative of the US Army Medical Research and Development Command (USAMRDC) for Grant no. DAMD17-86-G-6036 to the National Academy of Sciences for support of the Food and Nutrition Board's (FNB) Committee on Military Nutrition Research (CMNR), the CMNR met at the Pennington Biomedical Research Center in Baton Rouge, Louisiana on Sept. 19-20, 1991. The purpose of this meeting was to assist the Army in reviewing and evaluating the progress on work related to the USAMRDC Grant no. 17-88-Z-8023: "Effect of Food, Diet, and Nutrition on Military Readiness and Preparedness of Army Personnel and Dependents in a Peacetime Environment".

This Grant was established to implement this program for which funds were specifically allocated through the House Authorization Committee (DOD Appropriations Bill, 1988). An important consideration in the initiation of the Army funded program was that these funds were allocated for a 3 year period and the Pennington Center was not yet staffed or equipped. Initial proposals for one of these funds were developed by Louisiana State University (LSU) largely drawing on the interests and personnel available from the LSU Medical Center. As discussed in the letter report dated June 26, 1989, to Major General Philip K. Russell (see attachments), the Committee reviewed these proposals which were quite preliminary in nature. The proposal by Dr. Gerald Berenson came closest to meeting the criteria established in the Appropriations Bill. The Committee also recognized the value of establishing a research laboratory which could provide analytical support to the nutritional assessment program conducted by the Nutrition Research Group at Natick Laboratories.

The Committee on Military Nutrition Research's role in this preliminary review was to assist the Army with identifying research activities that fell within the mandate of the appropriation with the responsibility for the final decisions in program and funding with the Army.

Prior to assembling at the Pennington Biomedical Research Center, the CMNR reviewed: 1) an information paper and background materials, including the Grant Statement of Work, provided by COL Askew, the Grant Officer Representative; 2) the Final Report on USAMRDC Grant to the Pennington Center submitted by the principal investigator, Donna H. Ryan, M.D.; and 3) an earlier report prepared by the CMNR at the request of the USAMRDC reviewing this same research program in 1989. Copies of the information papers, the 1989 report from the CMNR, plus the meeting agenda and list of participants are attached.

On September 19, 1991 the CMNR convened at the Pennington Biomedical Research Center (PBRC) and heard presentations of the research accomplishments during the grant period from the Center staff and a statement from COL Askew. On September 20, 1991 the Committee met in executive session and reviewed the accomplishments of the Pennington Biomedical Research Center over the grant period in relation to the grant Statement of Work, the goals of the principal investigator, and their own previous recommendations. To provide supplemental expertise to the Committee membership in the area of neurotransmitters, the CMNR also submitted a copy of that part of the annual report of the Pennington Biomedical Research Center grant dealing with Project No. 3, Diet, Neurotransmitters, and Behavior, to two scientists currently working in this research area for confidential review. The Committee included the review of this outside team in their deliberations when writing this report. All CMNR members present at the meeting have seen and approved the report. Subsequent to approval of the final draft by the Committee, in accordance with National Research Council guidelines, this report was reviewed in confidence by a separate anonymous scientific review group. The Committee and advisors have reviewed the anonymous comments of this review panel and incorporated their suggestions where appropriate. Staff has then written a letter of response to the reviewers with the final report draft and obtained final approval of the report from the review panel. This report is thus a thoughtfully developed presentation that incorporates the scientific opinion of the CMNR, and the anonymous National Research Council reviewers.

Following is the Committee on Military Nutrition's evaluation of the research program presented to them and to Army personnel at the Pennington Biomedical Research Center.

General Comments

The Pennington Biomedical Research Center is a very impressive facility having an excellent physical plant for laboratory and clinical research. Considerable progress has been achieved in staffing and development of research activities since the CMNR's last visit on December 12, 1988. This has been made possible by financial support from the U.S. Army, USDA, and grants from NIH and other sources. In addition, the state of Louisiana has provided ongoing support at a level of $4.1 million dollars.

It is worthy of note that the new director for the PBRC, George A. Bray, M.D., has been appointed since the Committee's last visit. Dr. Bray, who is internationally renowned for his research in the fields of obesity and energy metabolism, has provided an important vision for the Pennington Center (which he is moving rapidly to bring to fruition). The progress noted builds effectively on the initial framework established by Dr. Allen Copping, President of the Louisiana State University (LSU) system, and on the ongoing administrative support of Donna H. Ryan, M.D., Project Director for the Military Nutrition Grant.

In general the Committee found that there was effective management support and guidance for the development of activities related to this grant. The progress in each project area was reviewed by the Committee and its assessment follows.

Specific Project Reviews

Project No. 1: Clinical Research Lab. This project is headed by Richard Tully, Ph.D. The major objective of this project was to provide biochemical assessment of nutrition status and to perform food biochemistry analysis. Significant progress has been made in securing necessary analytical equipment, implementing appropriate analytical procedures and most importantly, in implementing a sound quality assurance program. Dr. Tully has made significant progress in activating an effective clinical laboratory in a short period of time and in utilizing this facility to support requests from USARIEM. It should be noted that all of this has been accomplished with limited staff support.

The Committee is of the opinion that the Clinical Research Lab is a valuable resource to the Pennington Biomedical Research Center as well as being extremely valuable to USARIEM. The nutrition group at USARIEM has previously experienced difficulty in obtaining accurate and timely analytical information from outside contract laboratories. The ability to obtain important analytical data on military nutrition research projects in a timely manner greatly enhances the effectiveness of the nutrition research program. We recommend that the U.S. Army continue to provide partial support for this activity with the understanding that this resource be available on a priority basis to support U.S. Army studies. Further, the Committee supports the provision of additional resources to increase staffing of the Clinical Research Lab.

The staff of the Pennington Center has indicated a desire to develop a food analysis capability. The Committee recognizes the need for food analysis to support the clinical studies which the Center anticipates undertaking. In order to develop this capability effectively it is important to add an experienced food chemist to the Pennington Center staff. A major food analysis program would consume considerable resources both for methods development and actual analysis of various food components. Further, the undertaking of food analysis will require significant equipment additions and the staff should make judicious decisions regarding what analyses need to be performed beyond proximate analysis and inorganic elements. The CMNR believes that the breadth of activity necessary to establish a high quality food analysis laboratory would involve significantly more expertise, resources (equipment, personnel, and supplies), and facilities than is currently projected at the Pennington Biomedical Research Center. The Committee therefore holds that limited analysis on foods, related specifically to electrolyte balance, may be more within the scope of the laboratory's capabilities.

Project No. 2: Stable Isotope Lab. This project is directed by James P. DeLany, Ph.D. who has a good background in the use of stable isotopes to measure energy expenditure and body composition. The stable isotope technique provides a unique approach for use in free-living subjects since it is non-invasive and nondestructive. Consequently, it provides an ideal means of assessing important endpoints in experimentation valuable to the military.

The equipment that has been purchased and installed is state-of-the-art allowing Dr. DeLany to establish his methods and rapidly gear up his laboratory to support multiple studies. The Committee was favorably impressed with the quality and quantity of work completed thus far. In view of the expanding nature of military research projects which utilize stable isotopes in their protocols, the Committee recommends continued funding of the Stable Isotope Laboratory for priority support of military studies.

The staff of the Pennington Center have indicated a desire to increase the staffing of the laboratory by one additional Ph.D. scientist. In view of the importance of this methodology, the Committee would encourage such an addition if possible.

The availability of stable isotopes required for this work is currently limited and could curtail the ability to adequately support this area of research by the military as well as other investigations. The CMNR recommends that the military encourage the development of an adequate supply of the necessary stable isotope through combined efforts of the federal research establishment.

Project No. 3: Diet, Neurotransmitters and Behavior. This project is directed by Chandon Prasad, Ph.D. and has been staffed during the project period with five additional scientists on full or part time basis. In addition nine students have participated part time over the project period. The efforts to date have been devoted to developing the methodology for studying the effect of diet on behavior in animal models.

The CMNR believes that the area of nutrition and behavior is of military relevance, but the current research effort lacks focus and appears to have limited applicability to military concerns. The Committee is of the opinion that there is a need to further explore appropriate, relevant areas of research at the physiological and cellular level that are pertinent to military applications. This would require a reorientation of the current effort with considerably greater focus. It is suggested that the researchers develop more specific hypotheses which then can be investigated to better target the projects and to better determine the relevance to the military. The Committee notes that 25 percent of the funding provided by the Army has been in support of the research program of Dr. Prasad. The military has a major interest in the potential influence of nutrition on behavior particularly in those areas that may improve or maintain cognitive performance under combat stress. With the increasing sophistication of weapons systems there is a need to increase the capability of the individual to maintain mental acuity to function with these systems.

The lack of focus can be illustrated by listing the titles of the 15 projects reviewed. These were: 1) Behavioral neurochemistry of food-derived peptides; 2) Cyclo (His-Pro) and food intake; 3) Determination of tryptophan metabolites using HPLC; 4) Preparation and characterization of dopamine (D_2) receptor protein antibody; 5) Determination of dopamine (D_2) receptor messenger RNA expression; 6) Dopamine (D_2) receptor protein antibody mapping in the rat brain; 7) Dietary protein and behavior in rats; 8) Levels of dietary protein and modification of behavioral responses to CNS acting drugs; 9) Dietary protein and dopamine receptor regulation; 10) Effects of dietary protein on monoamines and monoamine metabolites; 11) Dietary protein and preparatory arousal in rats; 12) Dietary protein and neuronal plasticity; 13) Dietary protein and microtubule-associated proteins; 14) Dietary protein and brain amino acid profiles; and 15) Diet and stress.

Many of the studies involved the effect of dietary protein in brain chemistry neuronal structure and behavior. Most of these studies involved feeding rats diets up to 50% protein. In view of the vast literature involving studies of dietary protein in brain development and behavior in rats, the value of still more rat studies to the military has not been justified. In particular, the use of diets supplying 50% casein is questionable and of little relevance to human feeding in or out of the military. Several of the projects appear to be "fishing expeditions".

It is important that the research conducted under this program be well focused in order that its relevance can be evaluated both in long term and in applications to the near term. The CMNR recommends that a special site review be conducted in which efforts are undertaken to delineate major Army needs and review the Pennington Biomedical Research Center's program in light of responding to those needs with highly focused research. It is recommended that the site review team be composed of individuals who work directly in the area of nutrition, cognition, and behavior with expertise in the field of neurotransmitters.

Project No. 4: Fort Polk Study. The director of this study is Gerald S. Berenson, M.D. who initiated and developed the Bogalusa Heart Study. The project was completed in August 1991. The objective, as presented to the CMNR, was under the general title "Health Promotion Research and Assessment", and is "Assessment of Nutritional Status and Cardiovascular Risk of Military Dependents." While the Committee did not necessarily give this the highest priority rating in 1989, it was a project that could be implemented immediately. The study has achieved the objective of doing an nutritional/health risk appraisal of military dependents.

The second component of the Fort Polk Study was the development of a health promotion/education program for military families. It was unfortunate that the study did not have a larger sample size (n = 70 families) in the three cycles of families involved in the health promotion/education component. In addition, there was not a control group established for this component of the project. The CMNR also noted that the project report did not include any evaluation of the effectiveness of the program either on a short-term or long-term basis. For example, there was no measurement of changes from baseline measurements in behavior or other status indices.

It is the understanding of CMNR that this project has been completed, and future funding is not planned under this program. The CMNR would concur with this position. In the event that future plans might evolve to include implementation of such a health promotion program for military dependents, it is the position of the CMNR that a thorough review of the results of this study and delineation of desired objectives, including inclusion of methodology to evaluate long-term outcomes, should be conducted prior to implementation.

Project No. 5: U.S. Army Menu Modification Project. This project has been carried out by Evelina W. Cross, Ph.D. and Catherine Champagne, Ph.D. The results presented at the CMNR review were very preliminary, and the research team has been granted a no-cost extension to complete the requirements of the contract.

It is the consensus of the CMNR that the investigators were not sensitive to the needs of military garrison feeding program as demonstrated by the preliminary menus provided at the review. The project did not demonstrate any application of menu planning guidelines that would be appropriate in the military menu system, in terms of cost, acceptability, color, etc. Their first phase of menu modification did not meet the objectives of the project; the second phase brought fat down from 40 to 36% (not 30%), but did not appreciably reduce sodium or cholesterol (except when substitutions were made for breakfast eggs). The menus developed initially decreased caloric intake from 3,500 to 3,030 kcal. This lowered caloric intake might be considered a problem in some garrison situations. The menus developed to date and presented to the CMNR did not address cost, appearance, national food preferences, or relevance to the military feeding system.

The CMNR also questions whether the evaluation procedures used (college students consuming a meal as opposed to sensory evaluation panels, etc.) were applicable to the eventual user. Although, the project was incomplete when reviewed, the CMNR was not impressed with some of the approaches taken. The Committee further viewed the lack of interaction between the menu developers and the military menu system as a serious constraint on the ability of the investigators to achieve their objectives.

Therefore the Committee believes that this project, if continued, should be conducted in a military facility where the staff is more familiar with the military menu and procurement systems in order for a practical program to be developed.

Overall Conclusions and Recommendations

Generally, the Committee was impressed with the quality of the research activities at the Pennington Biomedical Research Center given the constraints of essentially starting from a zero base in equipping the facilities, recruiting staff, and initiating research activities, and felt that the funds provided by the U.S. Army grant had been effectively deployed. The CMNR would encourage continued financial support by the U.S. Army of those activities which have been and can continue to be relevant to the military namely the Clinical Research Laboratory and the stable isotope activity. Further, support of the area of nutrition and behavior should continue with attention to developing a project with greater focus and hence military relevance.

Sincerely,

Robert O. Nesheim (bm)

Robert O. Nesheim, Ph.D.
Chairman, Committee on Military Nutrition Research (CMNR)

Enclosures

cc: K. Shine
C. Woteki
D. Schnakenberg
E. Askew
B. Marriott

Appendix D

Letter Report: Committee on Military Nutrition Research Review of Three Research Proposals from the Pennington Biomedical Research Center

Submitted December 1992

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NATIONAL ACADEMY OF SCIENCES
2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

FOOD AND NUTRITION BOARD

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December 10, 1992

Major General Richard T. Travis
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Dear General Travis:

At the specific request of the COL Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM) who is Grant Officer Representative of the U.S. Army Medical Research and Development Command (USAMRDC) for Grant no. DAMD17-92-J-2003 to the National Academy of Sciences for support of the Food and Nutrition Board's (FNB) Committee on Military Nutrition Research (CMNR), members of the CMNR met at the Pennington Biomedical Research Center (PBRC) in Baton Rouge, Louisiana on June 3, 1992. The purpose of this meeting was to assist the Army in discussing plans for three projects that were proposed as part of USAMRDC Grant no. 17-92-V-2009 to the PBRC: "Military Nutrition Research: Six Tasks to Address Medical Factors Limiting Soldier Effectiveness."

This grant to the PBRC was established to implement a program for which funds were specifically appropriated through the Department of Defense Appropriations Bill, 1988. The CMNR has on two previous occasions reviewed the work related to this program of research at the PBRC and submitted letter reports with recommendations. The Committee on Military Nutrition Research's role at the meeting on June 3, 1992 was to assist the Army with identifying research activities that fell within the mandate of the appropriation. The responsibility for the final decisions in program remains with the Army. For this visit, the CMNR was asked to focus its attention on projects in the areas of neuroscience and menu modification.

Prior to the meeting, the CMNR reviewed 1) preliminary research proposals prepared by the scientific staff and principal investigator, Dr. Donna Ryan; 2) an information paper and background materials, including the Grant Statement of Work, previously provided by COL Askew; 3) the final report on the previous USAMRDC Grant to the Pennington Center submitted by Dr. Ryan; and 4) two earlier reports prepared by the CMNR at the request of the USAMRDC reviewing this same research program in 1989 and 1992. Copies of the meeting agenda and list of participants are attached (see attachment A).

On June 3, 1992 the CMNR convened at the Pennington Biomedical Research Center (PBRC) where they heard presentations and discussed the program orientations, goals, and preliminary research plans for three projects: basic neuroscience, clinical neuroscience, and menu modification. The role of the CMNR representatives at this meeting was as individuals participating in a discussion of scientific research directions. Since the committee is not in the position of giving real time advice, any comments made by the members of the group were not to be construed as recommendations from the committee.

Following the meeting, PBRC scientists prepared formal proposals describing their goals and research plans. The proposals were received by the committee on July 17, 1992 and the CMNR discussed the materials and drafted their report. The report was then reviewed in accordance with National Research Council (NRC) guidelines by a separate anonymous scientific review panel. This report, based in part on discussions from the meeting, review of formal proposals later developed by the scientists at the PBRC, and on executive session discussions by the committee, is a thoughtfully developed presentation incorporating the scientific opinion of the CMNR and comments of an anonymous peer review committee of the NRC.

Following is the Committee on Military Nutrition's evaluation of the research proposals as submitted (see attachment B in original report).

OVERALL COMMENTS

The CMNR continues to be impressed with the rapid expansion and development of the facilities and staff of the Pennington Biomedical Research Center. In only nine months since their last visit to the PBRC, significant new facilities have become available through the opening of the clinical research section and additional new laboratories. The leadership of Dr. George Bray and the important contributions of Dr. Donna Ryan to the overall program development on the U.S. Army grant were evident. The Pennington Biomedical Research Center provides an excellent environment for scientific study as well as superb facilities for research support services needed by the Army research programs. Now the challenge is to concentrate efforts in areas in which the PBRC can make a unique contribution to USARIEM's overall research effort, and to foster collaboration with other USARIEM research groups in similar areas.

The CMNR is concerned, however, after reviewing the protocols for the projects proposed by the PBRC, with what appears to be a lack of focus on the nutritional relevance of the projects to the military. The committee is also concerned about the lack of specific details in the protocols including the variables to be tested in most of the studies. There is also a concern that the complexity and practicality of conducting nutritional trials in people may not be adequately appreciated by the project leaders. While the committee realizes that the project proposals were not written as grant requests, it believes that the objectives of the projects should be clear and the protocols sufficiently delineated to clearly define the proposed work.

SPECIFIC PROJECT REVIEWS

Project No. 3: Nutritional Neurosciences Basic Science Laboratory

Project Summary

The purpose of project #3 is to investigate the mechanisms involved in REM (rapid eye movement, sleep phase) deprivation-induced cognitive dysfunction in the rat. Rats subjected to REM deprivation for 96 hours will be tested using behavioral, neurophysiological, and biochemical measurements to characterize the effects of sleep deprivation. Nutritional manipulations will be introduced after the sleep deprivation model is well characterized. These studies will determine if nutritional manipulations can sustain performance under conditions of REM deprivation in rodents.

General Comments

Sleep (specifically, rapid eye movement [REM] sleep phase) deprivation, and its direct and indirect functional consequences, is a common and significant stressor facing a large number of military personnel and is therefore an appropriate focus for investigation of dietary effects under this grant. A basic and central question is whether the program will focus on chronic changes in nutrition which might "protect" subjects from the negative consequences of sleep deprivation and other relevant stressors, or on acute changes in the diet (i.e., single meal or short-term supplementation). It is of fundamental importance to decide whether the focus of the proposed research will be an acute or chronic nutritional manipulation when developing the protocols for this research. It is suggested that the investigators refer to the many human and animal studies, for example those involving tryptophan and tyrosine supplementation, in planning and in setting priorities among the specific project protocols. A related issue is whether neurotransmitter precursor supplementation will be at physiologic or pharmacologic levels. In addition, while there is an understandable need for initial method development and refinement, the program seems to overemphasize procedural development to the detriment of dietary studies (at least as indicated by the written proposal and on-site discussions).

Notwithstanding, because the basic approach and methods are sound and the available staff and physical resources are adequate, there is a high probability that the program will meet its stated objectives. The neurochemical, histologic, electrophysiologic, and performance measures selected to assess dietary effects on sleep deprivation are appropriate and well-founded in the literature. Responses to comments made by the CMNR during the June visit adequately addressed the basic concerns of the members.

Specific comments, concerns and questions

1. The CMNR is pleased to learn that scientific staff of this project from the PBRC will be meeting with staff of the sleep research unit at the Walter Reed Army Institute of Research to discuss research plans and to develop a dialogue for future interaction. This is of primary importance in order to plan protocols that build on prior relevant research.

2. The committee voiced disappointment that no nutritional relevance was described in the basic project that is titled "nutritional neurosciences." It seems appropriate to expect that the basic studies laboratory should be testing nutritional hypotheses that relate to the clinical studies aspects of the same overall research program. Plans for dietary manipulations, including neurotransmitter precursor supplementation, are poorly described. The protocols for this research should relate to nutritional objectives with the plans for dietary manipulations, including

neurotransmitter precursor supplementation, clearly described. Ongoing advice from a nutritional scientist with expertise in dietary factors that alter behavior and neurotransmitter levels would assist in these efforts.

3. The number of animals proposed per group (8), although probably adequate to determine neurochemical, histologic, and electrophysiologic effects, may be insufficient to reveal proposed behavioral effects (e.g., changes in shuttle box performance).

Recommendations

- The goals of the project should be specifically detailed, clearly related to the nutrition objectives outlined by the Army, and cognizant of the many human studies dealing with nutritional entities or sleep and performance. Also, in the design it should be decided whether the emphasis will be on acute or chronic manipulations in developing the research protocols.

- The CMNR recommends that there be a major emphasis placed on increasing communication between the Basic and Clinical neuroscience groups at PBRC. This aspect of the program is necessary for integration of the research outcomes. There was some feeling among the committee membership that this proposal as presented, did not indicate enough ties to the clinical program and remains not particularly relevant to the military needs. Unless these ties become more evident, the project appears to be more appropriate for a standard individual proposal in a competitive grant arena rather than the present program.

- The research team should seek ongoing advice to strengthen the weak nutritional aspects of their experimental designs from nutritional scientists with expertise on dietary factors that alter behavior and neurotransmitter levels.

- Throughout the project the researchers should remain alert to unexpected changes in subject behavior and performance, as well as other functional effects, and have sufficient flexibility built into their program to pursue these effects experimentally.

- The inclusion of female animals as proposed, is important in future studies.

- The number of animals should be doubled when assessing behavior. In addition, a minimum of 15 animals per group is needed for the micropunch technique.

Project No. 4: Nutritional Neurosciences Clinical Studies

Project Summary

Project #4 involves human clinical studies of sleep deprivation with a mixed inpatient-outpatient design for a 12-day study. Measures of sleep efficiency, sleep stages, sleep onset, and sleep latency periods, neuropsychological tests, attention-demanding cognitive tests, neuroendocrine and immune function testing, and evaluation of the autonomic nervous system are planned. A listing is provided of potential neurotransmitter precursors that may be selected as nutrient loadings to assess their effectiveness in altering the effects of sleep deprivation. The authors state that several details that are missing from the research design will be determined through the planned pilot studies.

General Comments

The above comments regarding the issues of chronic versus acute dietary intervention and physiologic versus pharmacologic doses also apply to this program. Review of the written proposal and on-site discussion indicate that the scientific team has a thorough grasp of neurosciences literature on relevant concepts, methods, and measures. Impressively, the researchers recognize the "Catch-22" inherent in studies of factors which, on the one hand may potentially remedy sleep problems that directly and indirectly result in performance decrements, while on the other hand simultaneously would also likely interfere with attentional processes required for optimal performance during waking. Although there is no current solution to this issue, it is an important one to consider during data interpretation.

More details on the specific protocols are required before a thorough evaluation can be made. At minimum, it is necessary to discriminate among the "shopping list" of "dietary additives" that may be used. It is difficult to understand why the investigators cannot come forth with a short list of nutrients to be tested, and make reasonable judgement calls on dosages, duration of administration, and the timing as related to meals, sleep, stress, etc. In addition, if there is to be any hope of providing nutritional insight, vigorous efforts must be made to standardize the nutritional behavior of the subjects prior to initiating the protocol.

Little information is provided in the proposal regarding the mechanism of administration for the dietary additives, the amounts to be initially tried, etc., even though a number of possible substances are discussed. For a dietary study, one would expect a great deal more information regarding how the diet will be designed. Even Pilot Study II, which is designed to try out the "nutritional loading" to ascertain whether the protocol is appropriate, does not provide information regarding how the loading will be accomplished. It is obvious that the investigators purposely were trying not to be too specific, but someone needs to decide what substances and or modifications, or both, will be tried.

Specific comments, concerns and questions

1. The addition of a nutrition research scientist trained in conducting human dietary studies to the project team would provide needed expertise in dietary design and subject management.

2. The specific protocols should be better described and more relevant to the clinical objectives of the Army.

3. Manipulating caffeine increases the ecological validity of the results, but introduces the issue of "dietary" versus "nutrient component " intervention. Which, if not both, will be the focus of this program?

4. The investigators refer to the project as a "nutritional" study but, as pointed out, they intend to study substances found in foods at greatly increased levels. Rather than refer to these as dietary "additives," a more conventional term used by the regulatory agencies, industry, and the Congress would be dietary "supplements" if consumed as a tablet, capsule, or liquid, or a "food additive" when added to a food. If the expressed purpose is truly a pharmacological effect, then by law the term used should be "drug" regardless of how it is administered. The confusion over terminology and its ramifications further underscores the need for clarification of this aspect of the protocol.

5. Separating the stresses of caloric deprivation and sleep deprivation may be important. Previous research has shown that weight loss in obese humans is accompanied by marked increases in awakenings, that is, sleep

disturbances. While these findings are not directly relevant to the issue of the effects of sleep deprivation on military performance, they indicate that even short sleep deprivation periods may affect food intake and thus also neurotransmitter levels. In this project, therefore, how will food intake be kept constant to account for issues such as these?

6. The information provided does not indicate if Pilot Study II will test six different dietary additives (based on six subjects) or try one additive on the six subjects for a varying length of time. Since it appears that these will be outpatient studies, how will the investigators "...establish the time required to reach an effective level...?" It would seem that some of the blood work and sleep deprivation would have to be measured periodically as the load was titrated with subject response.

7. If automated (i.e., computerized) assessment of cognitive performance will be employed, it is imperative that subjects be thoroughly familiarized with the equipment and procedures prior to collection of critical data.

8. Instructions for the various cognitive test for the subjects were not addressed in the proposal. Clearly worded instructions are critical to avoid the confounding of speed-accuracy trade-offs frequently made when subjects try to compensate for stress effects.

9. The researchers might consider including a comparison of 1st, 2nd, and 3rd NREM period durations because several studies have shown a disruption of the predictable decline in NREM stage duration over the course of the night.

10. Problems with variability may be encountered when trying to determine urinary catecholamines using 8 or even 12 hour pools; 24-72 hour pools are often needed to reduce variability sufficiently to detect changes in urinary catecholamines.

11. In initially reading the proposal, one might assume that the pilot studies referenced in the first section would be in-house studies, with the larger community study planned as an outpatient study. Given the necessity to develop the methodology (Pilot Study I) and the level of dietary loading needed (Pilot Study II), it would seem extremely difficult to conduct these studies and obtain usable results from them on an outpatient basis. As an example, the number of venipunctures required within the minimum (7 days) or maximum (9 days) protocol length appears to be 56 (14 per day x 4 days during the protocol). This indicates the need for the use of

catheters for the repeated blood draws. Multiple timed urine collections will also be necessary. This really cannot be done on an outpatient basis. It is expected that subjects may try to sleep more (even if instructed not to) during the loading phase in preparation for the sleep deprivation days. Since the investigators are not controlling the subjects' activities or schedules, it seems particularly important, at least in the pilot studies, to be able to control all the variables that may be associated with the response.

12. Will subjects be supine for blood drawings collected for cortisol and catecholamines? Again, very high variability in catecholamine levels can be expected if subjects are not at rest for 15-30 minutes prior to sampling.

13. Despite the questionable reliability of dietary histories and food diaries to assess typical intakes, some such measure should be included to screen for atypical diet histories in potential subjects.

14. Will potential subjects be members of the military or matched to military personnel? It would be more helpful if military personnel were available to serve as subjects at the Pennington Center.

15. It is of concern that the investigators did not consider the venipuncture frequency or the amount of blood drawn as a risk to the subject. No mention was made of human subject panel review procedures, but it is assumed these will meet both LSU and U.S. Army standards and include full informed consent of all participants.

Recommendations

- Prior to initiation of either pilot study, a detailed protocol should be developed that clearly indicates how the concerns described in this review have been addressed. This protocol should include the diet, the specific dietary additives or manipulations that are to be tested, along with the method of administration, subject management (including characteristics that will preclude subject participation), methods for collection of physiological fluids, sleep deprivation routine, and test and performance measures. The protocols should reflect the clinical objectives of the Army.

- Ongoing participation of a nutritional scientist familiar with human dietary studies will provide needed expertise in protocol development and subject management.

- The stress of the repeated blood drawing should be evaluated (assuming that 14 venipunctures per day is what is actually planned), since no mention is made of cannulating the subjects.

- Any possible reactions to some of the neurotransmitter precursors (glutamine, etc.) must be discussed in advance with the subjects.

- It is difficult to understand how this project can be conducted on an outpatient basis and still maintain the level of control needed for data interpretation. It is recommended that serious consideration be given to having the subjects remain at the research facilities. This is routinely done in other research laboratories.

- Pilot studies will need to determine not only loading requirements but also cognitive and neuropsychologic tasks that are sensitive to sleep deprivation yet unaffected by repeated performance/measurement.

- Auditory noise is recommended as an excellent distractor in attention tasks because its parameters are easily controlled and quantified and it is easily administered. In addition, it is a relatively innocuous stimulus that is accepted well by almost all subjects and it is representative of real-world distractors.

- Addressing the neuroendocrine system is important because it may help determine whether stressors alter the metabolism of nutrients and whether nutrients alter the physiologic response to stressors.

- Smoking and exercise habits of potential subjects should be considered as screening factors because of their effects on food intake and sleep behavior.

- Careful consideration should be given to the issue of whether task/test administration is varied from day-to-day or kept constant. Fatigue and reduced motivation are likely given the large number of tests proposed.

- Throughout the project the researchers should remain alert to unexpected changes in subject behavior and performance, as well as other functional effects, and have sufficient flexibility built into their program to pursue these effects experimentally.

- The inclusion of female subjects is important in future studies.

Project No. 5: Menu Modification Project

Project Summary

The Menu Modification Project has evolved to include changes that address some of the concerns expressed in previous discussions. Specifically, during Phase II of the project, modified recipes will be substituted in the standard menu, and acceptability testing will be conducted. These modified recipes will be lower in fat, cholesterol, and sodium. Phase III will include a week in which modified menus will be served and a week of standard menus. Food acceptability will be assessed using computerized score sheets to be handed out at each meal during Phase III. Additionally, during Phase III, surveys regarding nutrition knowledge, practices, etc. will be administered by graduate students. The proposal calls for developing modified menus and testing their acceptability in a "real" situation at Fort Polk. Acceptability will be ascertained by means of a simple 9-point hedonic rating.

General Comments

The key to success of this project is the ability to develop acceptable menu items that achieve the stated objectives. The specific menu items to be altered and the ingredient targets for change are not clear. It appears that this will be a serendipitous process. There is no indication of any study of the major contributors of fat, saturated fat, cholesterol, or sodium in current menus. Such information would permit a better defined approach to menu modifications. For example, it is predictable that eggs are the major contributor to cholesterol intake, therefore, it is reasonable to suggest that removing eggs from the menu by providing alternative/substitute menu items would lower cholesterol intake. Further, since eggs are generally consumed at breakfast it is likely that the major impact would be at that meal. Indeed, this was the reported observation.

It would seem that a project such as this could benefit from a computer analysis of menus and the food menu item contribution of fat, saturated fatty acids, cholesterol, and sodium. The major contributors could then be targeted for modifications. Better computer modeling would provide options for selecting alternative means for evaluating the dietary plans.

The collection of consumption information will be critical in assessing whether compensation for the fat reduction occurs. The proposal indicates that this will be monitored by USARIEM personnel but few details are provided.

The importance of this information should be stressed and every effort made to insure adequacy of these data.

It is essential that closer linkages be developed with Army experts who are in charge of the Master Menu and food service facilities. Without review and critique of ideas earlier in the menu item development process, little that is truly useful for the special circumstances under which Army food services must operate is likely to be accomplished. For example, Army food services must operate within strict financial allocations. Many of the suggested changes would likely be hard to accommodate within current allocations. Furthermore, the basic premise that foods that are developed and taste-tested by college students at Pennington are going to be exportable to the U.S. Army is of doubtful validity. Since all of the proposal is based on that premise, very serious consideration must be given to the whole concept of the project.

The proposed add-on graduate research projects seem of low priority. If these tasks interfere in any way with the major objectives of the project they should be dropped.

Specific comments, concerns, or questions

1. It is unclear whether modified menu <u>items</u> will be substituted in the standard menu in Phase II or modified menu <u>days</u> will be substituted.

2. It is unclear whether the acceptability testing during Phase II will be only on the modified menu items (or days depending on the answer to #1) or also on the standard menu items for which they are substituted (such as low fat biscuits versus standard recipe biscuits, etc.). Such a comparison would provide a control data base, and prevent respondents from identifying the new items as "different", which may bias their future thoughts on the items.

3. In Phase III, it appears that one week of standard menus will be followed by the week of modified menus. (Or, will the seven days of each set be intermingled with daily testing conducted?) It is important to make sure that the same individuals (to the extent possible) participate in both standard and modified menu acceptance testing. With schedule changes for personnel, might there be a different group eating in the garrison the first week versus the second week? If so, it would be necessary to intermingle the modified days with the standard days.

4. Will the graduate student surveys be administered only during the week of modified menus, or will they be administered randomly between both weeks? The presence of the graduate student surveys may affect (at least temporarily) the respondents' food selection patterns, thus it would be important to make sure that questions were asked during both the modified and standard meals.

5. No research design is provided for either part of Phase III. What data are to be collected? How are interfering variables to be controlled? How are the data to be analyzed?

6. The evaluation form provided is not adequate to determine acceptability. Also, why does the score sheet to be given to the troops list a "Code" for the menu item? This could surely be accomplished in another less obvious way.

7. In addition, the acceptability trial is too simplistic. One overall scan for a menu item is not adequate. Questions need to be asked that reflect various aspects of preference, not just a single overall score.

8. Sensory testing results need to be compared with acceptability scores versus actual ingestion. It is important to remember that highly preferred foods (such as desserts) are not necessarily eaten frequently, while moderately preferred foods, for example, bread, are eaten daily.

9. Clear mention and delineation of important principles of menu development including such factors as variety, flavor, color, texture, etc. need to be included in the project objectives and project plans.

10. The issue of ethnic food preferences must be addressed in the project plan.

11. It is suggested that an Advisory Committee of NCO's be established at Fort Polk to advise the project staff. This committee would be analogous to the use of student advisory groups in school feeding programs.

12. As a result of the travel distances and time involved, the use of graduate students to collect data at Fort Polk is very inefficient and may be costly. There may be experienced dietitians, as dependents at Fort Polk or its environs, who would be interested in working on this project. This alternative at least should be explored.

13. The nutrition knowledge and nutrition education components are not relevant to the basic mission of this particular project and should receive lowest priority.

14. The committee is not enthusiastic about ancillary graduate student projects in the area of nutrition education. There is considerable likelihood that such activities will be disruptive and are not likely to yield information of consequence. Unless a much more persuasive argument can be put forth the ancillary graduate student research projects should not be undertaken.

15. The committee does not see enough evidence of the kind of expertise needed for this project in the two curriculum vitae that accompanied the proposals. The lead investigator has good expertise with data bases, but has little experience with large scale food services. The chef is dedicated but also an individual with little experience in very large scale food service with tight cost and ingredient constraints. Someone who had formerly been involved in Army food service would bring more realistic perspectives to the task. As a result, the investigators should lean very heavily on the expertise of personnel involved with Army food service.

Recommendations

- The specific objectives of the project need to be written down so the results of the project can be evaluated, for example, targets need to be delineated for fat, cholesterol, and salt reduction, acceptability level, nutrient composition (including the relationship to the current Military Recommended Dietary Allowances [MRDAs], etc.

- A systematic approach to the menu modification project should be carefully described, for example,

  a) initially a schedule of interactions should be outlined that will take place with Army menu planners to ensure that the project investigators fully understand the menu development process, cost restrictions, etc., and to insure relevance of the planned project to future use in Army menu development;

  b) extensive computer modeling should be planned that is based on interaction as suggested in (a) to identify the best opportunities to modify menus to meet objectives as established in the first recommendation stated above;

c) initial acceptance criteria for modified items need to be clearly developed; and

d) a detailed plan for adequate testing in an adequate military setting must be established.

- Plans for familiarization with actual preparation capability in the Army menu system must be made to obtain a clear understanding of the actual sites and circumstances under which meals are prepared in the Army, more understanding of the preferences of personnel, and more understanding of the Master Menu and other procedures.

- The investigators need a more intimate and comprehensive working relationship with USARIEM.

- Staff on the project should include those who have expertise and credentials in large scale menu planning, and previous experience working with the Army food services.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

The first two programs in particular address high priority research questions, employ creative yet sound experimental methodologies, and have the potential to yield unique and important insights for the broader question concerning the relationship between diet/nutrition and function, with far reaching applications. However, because these projects may impact not only broad scientific objectives and hypotheses, but also specific future scientific methodology and measurement, it would be important to see the philosophy guiding this research clarified with respect to the scientific issues of acute versus chronic and pharmacologic versus physiologic dietary intervention. Frequent and meaningful communication between the Basic and Clinical neuroscience researchers will greatly benefit both programs. In contrast, the CMNR has serious concerns about not only the staffing but also the adequacy of the approach of the menu modification program.

The physical resources available at the PBRC are adequate to accomplish these three projects. While the overall staffing for the basic and clinical neurosciences projects appears well developed, the CMNR believes the projects require on going advice from nutritional scientists with expertise in dietary factors that alter behavior and neurotransmitter levels. This could be accomplished through the addition, at least as consultants on a regular basis, of nutrition research scientists who are trained in conducting human dietary studies. The committee has reservations about the relevance and appropriateness of the menu modification project. Without appropriate planning, coordination, and staffing this project cannot make a significant impact on modifying Army menus in keeping with current healthful diet concepts. If improperly executed it would likely be a waste of time and resources.

The CMNR is pleased to provide this review as part of its continuing response to the U.S. Army Medical Research and Development Command.

Sincerely,

Robert O. Nesheim, Ph.D.
Chairman, Committee on Military
Nutrition Research

Enclosures

cc: D. Schnakenberg
E. Askew
K. Shine
C. Woteki
B. Marriott

Attachment A

AGENDA
COMMITTEE ON MILITARY NUTRITION RESEARCH VISIT
JUNE 2-3, 1992

<u>June 2, 1992</u>

4:00 - 5:30 p.m.	Dr. Ryan and Dr. Bray meet with Colonel Askew and Colonel Schnakenberg

<u>June 3, 1992</u>

7:00 - 8:00 a.m.	Breakfast and demonstration of modified menus
8:00 - 8:15 a.m.	Introduction from Dr. Bray
8:15 - 8:30 a.m.	Overview of new projects by Dr. Ryan
8:30 - 9:00 a.m.	Introduction of Dr. Kumar - LSU Medical Center - New Orleans, Dr. Tulley, Dr. Delany
9:00 - 10:00 a.m.	Discussion of Clinical Neuroscience Studies Project -Drs. Waters, Magill and Williamson
10:00 - 11:00 a.m.	Discussion of Basic Neuroscience Studies Project - Drs. Prasad and Berthoud
11:00 - 12:00 noon	Discussion of Menu Modification Project - Dr. Champagne
12:00 - 1:00 p.m.	Lunch and demonstration of modified menus
1:00 p.m.	Adjourn

Attachment A *Continued*

COMMITTEE ON MILITARY NUTRITION RESEARCH (CMNR)
SUB-COMMITTEE MEETING
JUNE 2-3, 1992

Discussion Meeting at the Pennington Biomedical Research Center

PARTICIPANTS

<u>CMNR</u>
<u>U.S. Army</u>
Robert O. Nesheim, *Chair*
COL David Schnakenberg
James Penland, *Special Consultant*
MAJ John Leu
Johanna Dwyer, *FNB liaison*
COL Wayne Askew
Allison Yates
Harris Lieberman
MAJ Cecilia Thomas

<u>Staff</u>
Bernadette M. Marriott, *Program Director*

<u>PBRC Staff</u>
George Bray, *Director*
Donna Ryan, *U.S. Army Grant principal investigator*
Hans-Rudolf Berthoud
Catherine Champagne
Richard A. Magill
Chandan Prasad
William F. Waters
Donald A. Williamson

Appendix E

Conclusions and Recommendations from the Workshop Report: Body Composition and Physical Performance

Submitted August 1992

Conclusions and Recommendations

CONCLUSIONS

As stated in the Introduction, the Committee on Military Nutrition Research (CMNR) was asked to respond to seven specific questions dealing with the body weight and composition standards of the military. The committee's responses to these questions are as follows:

1. Can or should physical performance assessments be used as criteria for establishing body composition standards in the services?
Aerobic fitness, as assessed by the current physical training tests, is an appropriate indicator of physical fitness for military personnel. However, serious consideration should be given to developing job-related performance tests, such as lifting and carrying tasks, that are more closely related to actual military activities. These tests should be used to help develop body composition standards that are more closely related to physical performance of military tasks.

2. What is the relationship between body composition and performance?
Within the range of body composition exhibited by current military personnel, there is no consistent relationship between body fat content and physical performance. There is, however a direct relationship between physical performance as measured by tests of load carrying ability and lifting abilities and the amount of lean body mass.

3. The services currently use a maximal body fat standard. Should they also establish a minimum fat-free or lean body mass standard?

In view of the positive relationship between fat-free or lean body mass and physical performance, the military should seriously consider establishing a minimum standard for lean body (that is, fat-free) mass. There is doubt among the members of the CMNR as to whether the military should continue to employ a maximal body fat standard.

4. What factors should be considered in setting body composition standards?

A body composition standard in the military should be based primarily on ability to perform required physical tasks and secondarily on long-term health implications. A stronger rationale needs to be developed for basing the standard. This conclusion relates only to service-wide standards, not the more stringent standards required for particular military occupation specialties.

5. Are performance and body composition standards redundant?

If job-related performance standards were in place, a body composition standard would be unnecessary in relation to physical performance.

6. If performance criteria exist, are weight-fat standards needed?

Because body weight and composition have health implications entirely aside from the question of physical performance, such standards are desirable. Also, if the military determines that appearance is a sufficiently critical factor that it outweighs the cost of enforcing weight/fat standards, then appearance standards would be needed.

7. How does one rationalize the different uses of body composition for performance, appearance and health?

As stated above, body fatness is related to long-term health, and lean body mass is related to some aspects of physical performance. Appearance of different individuals at the same body weight and fat content can vary considerably depending on other factors. A stronger rationale for appearance criterion and standards that define acceptable and unacceptable appearance need to be developed.

RECOMMENDATIONS

On the basis of the papers presented by the invited speakers, discussion at the workshop, and subsequent committee deliberations, the Committee on Military Nutrition Research (CMNR) presents the following recommendations to the Army Medical Research and Development Command regarding body composition and physical performance as it relates to accession and retention standards for the military services:

- All services should develop job-related physical performance tests to use for accession into military service.

- The differences between accession and retention standards for body weight need reevaluation for all services.[1]
- An inequity exists in body composition standards for men and women. Accession and retention standards for body weight and body fatness in men and women should be reevaluated in the light of all factors discussed in this report.[1]
- The appropriateness of current body composition standards needs to be validated for the significant ethnic groups represented in the military services.
- A relationship between trim military appearance and military performance could not be identified. If the military determines that a trim military appearance is important, objective criteria should be developed to the extent possible for appearance evaluation.
- For individuals who face separation from the service for failing to meet body composition standards, it is suggested that the military identify a limited number of military centers that can perform more specific measurements of body composition (for example, dual photon densitometry, underwater weighing, and body water) and to which the individuals in question could be referred for further evaluation.

AREAS FOR FUTURE RESEARCH

The Committee on Military Nutrition Research (CMNR) suggests several areas for future research within the military related to body composition and physical performance. The CMNR believes that the military services, through its pool of volunteer personnel, have an excellent and often unique opportunity to generate statistics about nutrition, health, and well-being of service personnel that can be directly applied toward improved health of

[1] In April 2, 1991, Dr. J. A. Vogel and MAJ K. E. Friedl, Occupational Health and Performance Directorate, U.S. Army Research Institute of Environmental Medicine, presented a briefing and a proposal for revisions to Army Accession (AR 40-501) and Retention (AR 600-9) Standards to LTG Reno. These recommendations (See Appendix D) were approved at the briefing. As a result, on May 7, 1991 the Army retention standard (AR 600-9) was amended for women by increasing the allowable percent body fat standards by 2 percent body fat units for each age group as follows: 17-20 y: formerly 28 percent amended to 30 percent; 21-27 y: formerly 30 percent amended to 32 percent; 28-39 y: formerly 32 percent amended to 34 percent; 40+ y: formerly 34 percent amended to 36 percent. Changes to the Army Accession Standard (AR 40-501) as proposed went into effect on October 1, 1991. These changes result in the Army switching to a body fat standard for accession, reducing the accession standard for men to not exceed 4 percent body fat units over retention fat standards, and make the body fat accession standards for women the same as the newly revised retention standards (Appendix E).

military personnel and for the general U.S. population. Research on the following topics is recommended:

- the development of service-specific standard tests of military performance that more accurately reflect military activities;
- the relationship of body composition to military and physical performance among men and women, including consideration of the relationships of lean body mass, height, and physical performance;
- the relationship of body fat distribution and body composition to long-term health outcome in career military personnel, specific for race and gender; and
- the relationship of injuries to components of body composition (specifically bone density and lean body mass).

Two additional areas of research were not specifically mentioned in the task posed to the committee for this project however, in view of the unique opportunities available for research within the military setting and afforded by its data bases, the CMNR recommends that the military conduct research in these areas to increase general knowledge related to body composition and physical performance:

- a retrospective study of the Medical Remedial Enlistment Program (MREP) data base to evaluate (a) long-term health status and performance of overweight recruits and overweight personnel in general, and (b) cost-benefit analyses of enrolling individuals who are overweight at the time of enlistment.
- the relationship of body composition to emotional and psychological factors in military units: (a) psychological effects of being overweight and underweight on individuals in a military setting, (b) psychological effects on unit morale of having overweight and underweight individuals present in the unit; and (c) an evaluation of officers' and noncommissioned officers' attitudes and possible biases toward the presence of overweight and underweight individuals in potential combat situations.

The Committee on Military Nutrition Research is pleased to participate with the Division of Military Nutrition, USARIEM, U.S. Army Medical Research and Development Command, in programs related to nutrition and health of American military personnel. The CMNR hopes this information will be useful and helpful for the Department of Defense in developing programs that continue to improve the lifetime health and well-being of service personnel.

Appendix F

Conclusions and Recommendations from the Workshop Report: Nutritional Needs in Hot Environments

Submitted March 1993

Conclusions and Recommendations

CONCLUSIONS

As stated in Chapter 1, the Committee on Military Nutrition Research (CMNR) was asked to respond to 11 specific questions dealing with nutrient requirements for work in hot environments. The committee's responses to these questions appear below:

1. What is the evidence that there are any significant changes in nutrient requirements for work in a hot environment?

Sensible and insensible water losses are increased markedly by work in a hot environment, resulting an increased need for water. In general, energy requirements decline somewhat in a hot environments, primarily because of the tendency to reduce activity. However, other factors, including the degree of acclimatization, may modify the body's energy requirement in the heat. In addition, there is considerable individual variation. Recent evidence suggests that slight increases in protein may be required for work in hot environments, however the MRDA already includes an amount sufficient to meet this increased level given adequate consumption of kilocalories. Significant losses of several minerals occur with profuse sweating; however, current methodology does not provide data that indicate the need for measurable increases in requirements. Based on losses in sweat and the potential for dehydration people working in hot environments may require additional sodium and other electrolytes. Vitamin requirements do not appear to increase with exposure to a hot environment; however, few studies have examined this issue. In particular, the role of antioxidant vitamins (A, C, and E) in reducing exercise-induced lipid peroxidation induced by exercise in a hot environment should be examined.

2. If such evidence exists, do the current Military Recommended Dietary Allowances (MRDAs) provide for these changes?

The variations in nutrient requirements, including sodium, that may occur as a result of working—and sweating—in a hot environment are reasonably covered by the nutrient content of the MRDAs, because the MRDAs provide generous allowances over most nutrient requirements. If military rations are consumed in amounts that approximate energy expenditures, it is likely that the nutrient requirements of soldiers will be met.

3. Should changes be made in military rations that may be used in hot environments to meet the nutrient requirements of soldiers with sustained activity in such climates?

Based on the evidence available at this time, the nutrient content of military rations does not need to be changed. Nevertheless, because appetite is depressed and food preferences and eating patterns are changed in response to short-term and long-term exposure to heat, changes should be made in ration components to enhance intake. Military feeding in hot environments needs to take into account what is known about these changes in food preferences and meal schedules. The components of the rations and field feeding environments should be adjusted to encourage consumption of military rations. Convenience and acceptability become all important.

4. Specifically, are the meals, ready-to-eat (MREs) good hot weather rations? Should the fat content be lower? Should the carbohydrate content be higher?

The nutritional composition of MRE rations is appropriate for use in a hot environment. There are no consistent data that suggest that the relative proportions of protein, carbohydrate, and fat should be altered. It is clear, however, that the experience gained during Operation Desert Storm regarding the acceptability of the various MRE rations and ration components needs to be evaluated.

Significant components, including the entrees, in the MREs available in 1991 required heating to provide the most palatable meal. As noted in anecdotes from those conducting observations in the Persian Gulf area during hot weather, the shift in soldiers' food preferences to a desire for cooler items (salads, sandwiches, etc.) confirms that the MREs were not designed specifically for long-term consumption in hot climates. Data from animal studies show an increase in fat consumption in the heat, with a decrease in protein consumption. As a result of the organoleptic changes in fat within foods in conditions of extreme heat however, food products that contain significant amounts of fat may be deemed unacceptable by soldiers and thus may not be consumed.

The requirement for sustained physical activity in hot environments might result in the need for a modified ration that would encourage food consumption, for example, one lower in fat and higher in carbohydrate that could be consumed with little preparation. Heat-stable food products that are similar to those available in the private sector appear to be preferred by soldiers in terms of appetite. In designing MRE rations for use in hot environments, information from the experience gained during Operations Desert Shield and Desert Storm should be combined with what is known about how food preferences change in the heat. Moreover, factors other than ration composition that may influence food intake need to be considered. These include the availability of potable liquids in generous supply, the eating situation of troops (i.e., alone or in groups), the time of day when food may be offered, and the convenience of consuming the rations. Nonnutritional factors such as these can have a significant influence on ration intake.

5. What factors may influence food intake in hot environments?

The major factors that appear to influence food intake in hot environments are the need to maintain body temperature (through decreased intake to reduce the thermic effect of food) and the apparent relationship between decreased body weight and decreased body temperature. With the hydration regimens in place in the military, which appear to encourage adequate fluid intake, and the awareness among military personnel of potential heat stroke, the observation in laboratory animals of markedly decreased food intake to prevent hyperthermia is probably not a significant concern within the military population.

Other factors such as psychological stress may further depress food intake. In addition, the lack of a desire in hot environments to eat hot foods (even though their palatability may be greater than that of cold foods), and the concomitant increased desire to consume cold foods is documented somewhat subjectively in nationwide surveys of food intake of individuals from households in the U.S. general population during various seasons. The intake of food by humans in a hot environment may be further influenced by the availability of cool potable water, the time of day, the psychosocial environment, and ration components.

6. To what extent does fluid intake influence food intake?

Animal studies demonstrate that dehydration markedly decreases voluntary food intake and that forcing foods during dehydration results in increased mortality. Although there have been a few human studies of this question, it appears that rehydration is necessary in humans before depressed food intakes returns to normal. To maximize the energy intake of military personnel in hot environments in which significant physical activity is required, maintenance of adequate hydration status should be a primary objective of all policies related to soldier readiness. Maintenance of states of proper hydration was also identified as the most critical issue facing soldiers in desert environments in an Army report on food management issues written during Operation Desert Storm (Norman and Gaither, 1991). The recent CMNR report *Fluid Replacement and Heat Stress* (Marriott and Rosemont, 1991) thoroughly addressed this issue.

7. Is there any scientific evidence that food preferences change in hot climates?

Several animal studies document changes in food preferences in hot environments. There are also a limited number of studies that show decreased caloric intake in humans when working in a hot environment. Most of these studies did not allow for acclimation of subjects to the hot climate. In the one major study that did, food intake decreased less markedly in the acclimated individuals, with no change in per cent distribution of kilocalories from fat, carbohydrate, or protein. In the summer season food choices do change, but whether due to environmental temperature or other factors such as price and availability have not been well established. Thus, to date, most information on changes in food preferences in humans are limited to anecdotal observations or studies that were not balanced with respect to temporal adaptation to climatic change.

8. Are there special nutritional concerns in desert environments in which the daily temperature may change dramatically?

If rations are consumed in adequate amounts, no specific nutrient concerns need be addressed as a result of the dramatic changes in temperature that frequently occur in the desert. Adequate intake of fluid to avoid dehydration and help maintain food intake is obviously important. The levels of nutrients specified by the MRDAs appear to be adequate to meet the nutrient needs of soldiers if rations are consumed in appropriate amounts.

9. Is there an increased need for specific vitamins or minerals in the heat?

Although small increases may occur in the losses of B vitamins in sweat during work in hot environments, these losses do not appear to be great enough to justify increasing the requirement over that established in the MRDAs. There is limited evidence that vitamin C may have an effect in reducing heat stress during periods of acclimatization, particularly if the individual has had a low vitamin C intake prior to exposure to the heat. However, there is insufficient evidence at this time to recommend an increase in vitamin C beyond that currently supplied by the MRDA.

Prolonged moderate- to high-intensity activity in hot environments will result in a significant loss of electrolytes (sodium, potassium, magnesium), particularly among troops who are not adapted to hot environments. However, if fluid intake is maintained to prevent dehydration and consumption of military rations is at or near energy requirements, sufficient intake of electrolytes should occur.

10. Does working in a hot climate change an individual's absorptive or digestive capability?

There is evidence that gastric emptying may be reduced during heat stress. Although, the mechanisms responsible for this observation are unclear, they may be associated with dehydration, which frequently occurs when working in the heat, with reduced splanchnic blood flow. Studies have also demonstrated that elevations in core body temperature can reduce stomach and intestinal motility. It is apparent that maintaining adequate fluid intake is important as an aid in reducing heat stress from working in a hot environment.

Limited evidence suggests that net calcium absorption may be reduced as a result of increased fecal losses during profuse sweating while working in hot environments. Some investigators have reported reduced intestinal absorption during exercise. However, other studies, by using more direct techniques of segmental perfusion, have shown no effect of either exercise intensity or duration on fluid absorption. In short, individuals who are well trained, acclimatized to heat, and accustomed to endurance exercise seem to experience fewer symptoms of gastrointestinal stress than less-well conditioned and acclimatized individuals.

11. Does work at a moderate to heavy rate increase energy requirements in a hot environment to a greater extent than similar work in a temperate environment?

Uncertainty exists about the influence on energy requirements of working in the heat (see Chapter 6). Submaximal exercise in a hot environment does not appear to have an impact greater than beyond that occurring in a more comfortable environment. Maintaining adequate food intake in the temperature extremes of hot environments to meet caloric needs is a higher priority than concern over small differences in energy requirements.

RECOMMENDATIONS

On the basis of the papers presented by the invited speakers, discussion at the workshop, and subsequent committee deliberations, the Committee on Military Nutrition Research finds that the nutritional requirements for work in hot environments are not significantly different from that needed in more moderate conditions. The nutrient content of the military's operational rations is adequate to provide for any variation that may occur as a result of work in the heat. There are, however, significant concerns about inadequate intakes of soldiers engaged in field operations, exercises, or combat in that the nutrients actually consumed may be less than the amounts specified in the MRDAs. Special attention should be given to ensuring that the intake of rations by soldiers is adequate to meet caloric needs, thereby ensuring that each individuals nutrient requirements are met. Of primary consideration is maintaining adequate fluid intake to avoid dehydration and consequent decreased food intake. This topic has been addressed in a previous CMNR report, *Fluid Replacement and Heat Stress* (Marriott and Rosemont, 1991). The committee wishes to reiterate that water is the most important nutrient for maintaining the performance of the soldier.

The committee offers the following recommendations regarding nutrient requirements for work in hot environments.

1. The maintenance of adequate hydration should be the major objective of efforts to maintain the sustained performance of troops in hot environments. As recognized by current Army doctrine, water is an essential nutrient.

2. *Maintaining an adequate intake of operational rations should also be an important objective to insure that troops will meet their nutritional needs over the course of extended military operations. It is recommended that a study be conducted to determine why soldiers don't usually consume adequate amounts of food to maintain body weight under operational conditions, and to evaluate steps that may be taken to achieve adequate ration intake.*

3. Given the decreased food intake that usually occurs in hot environments, changes should be made in rations and their components to enhance

appetite and food intake. These changes should include ensuring the delivery of a variety of ration options to avoid menu fatigue.

4. Delivery systems and feeding situations should be designed to enhance intake and take into account the environmental factors, including psychosocial factors, that influence food consumption. The following should be considered:

- availability of cool, flavored, potable water,
- a cooling environment such as shade,
- time of day for meal service,
- the social situation during meals,
- ration preparation requirements,
- use of familiar commercial food products, and
- ethnic food preferences.

5. Variations in ration components for different environments (hot-dry, hot-humid, moderate, and cold) should be evaluated.

AREAS FOR FUTURE RESEARCH

The Committee on Military Nutrition Research suggests a number of areas for future research within the military related to nutrition for soldiers working in hot environments. The CMNR believes that the military services, through their pool of volunteer personnel, offer an excellent and often unique opportunity to generate research data and statistics on the nutrition, health, and well-being of service personnel. These findings can be directly applied to improve both the health of military personnel and that of the general U.S. population.

Future Research Needs

- The decreases in food intake that normally occur in hot environments and the previous lack of research emphasis on this subject urge the investigation of factors that affect food intake in a hot ambient environment. Such factors include but are not limited to the following:

—environmental conditions in the dining situation such as meal setting, menu item variability, food item temperature, social setting, and meal timing and frequency;

—ethnic and gender differences in food preferences;

—the relationship of food preferences to climate, with a focus on carefully controlled studies of the same individuals in temperate and hot environments (both dry and humid);

—chemosensory perception of foods and menus in relation to climate; and

—composition of the ration, that is, proportion of fat, carbohydrates, etc.

- In addition to the application of current biochemical indicators, an important area of research is the development and validation of appropriate functional indicators of nutritional status, with an emphasis on vitamins and minerals for which sweat losses are significant. These functional indicators should relate to endurance, immunity, antioxidants, nutrient deficiencies, and recovery from illness/trauma. A particular concern would be the iron status of military women under conditions that produced significant sweating.

- The potential role in stress responses of higher dietary intakes of zinc, vitamin C, and other antioxidants could be explored further with emphasis on heat stress.

- Studies that focus on gastrointestinal function in the heat are important. In particular, the effects of various levels of militarily relevant physical activity and the interaction of physical activity with psychological stress and gastrointestinal function.

- More research is needed to evaluate the impact of adequate mineral intake on physical performance in a hot environment. Such research would allow the development of more specific recommendations concerning circumstances in which mineral supplements or food fortification is indicated. In particular, studies are needed that separate the effects of exercise from the effects of an elevated ambient temperature, and studies that evaluate the effects of higher levels of mineral intake on functional indicators.

- Does heat enhance satiety or impair hunger? These questions could be addressed through research that more specifically addresses whether the effect of heat on appetite suppression is expressed in terms of smaller meals—presumptive satiety effects—or less frequent meals—presumptive hunger effects.

The Committee on Military Nutrition Research is pleased to participate with the Division of Nutrition, U.S. Army Research Institute of Environmental Medicine, U.S. Army Medical Research and Development Command, in programs related to the nutrition and health of American military personnel.

The CMNR hopes that this information will be useful and helpful to the Department of Defense in developing programs that continue to improve the lifetime health and well-being of service personnel.

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Appendix G

Conclusions and Recommendations from the Brief Report: Review of the Results of Nutritional Intervention, Ranger Training Class 11/92 (Ranger II)

Submitted June 1993

Part II

Questions Posed to the Committee, Answers and Discussion

In the following section the five questions posed to the committee are specifically answered. After each answer the CMNR presents an overview of their reasoning and rationale, as well as their recommendations as they relate to the question posed. The CMNR recognizes that this was an operational study and that complete control over all experimental variables was not always possible.

Question 1: Was the nutrition intervention (increasing energy provision by 10-15%) effective in decreasing medical risk?

Answer: The outcomes from Ranger II were different from Ranger I. In addition to the increase in energy provision, other interventions were introduced in Ranger II. Ranger I and II were not done simultaneously, thus the possibility of alterations in behavior of both cadre and students is present. In Ranger II, this may have resulted in increased attention to provision of food and/or water and increased vigilance directed towards preventing health related problems based on lessons from Ranger I.

In the Ranger II study the following interventions differed from the Ranger I study:

- there was increased energy intake throughout the Ranger II study;
- there was an increase in protein intake during the field training exercises in Ranger II;
- the sequence of training sites was changed;
- field rations were changed at mid point of Ranger II;

- there was an increase in activities, voluntarily or involuntarily during Ranger II, as determined from increased energy expenditure;
- anecdotally, there were suggestions that there was an increased use of knee pads or perhaps other protective coverings that may have affected the number of abrasion, punctures, etc. suffered by soldiers in Ranger II; and
- additional testing, in particular the cognitive function tests, were added to the Ranger II study.

The following outcome differences were noted:

- Ranger II trainees exhibited increased energy intake and increased energy expenditure when compared with the Ranger I trainees;
- body weight and percent body fat were preserved to a greater extent in the Ranger II study;
- the high frequency of extremely low levels of percent body fat that were seen in the Ranger I trainees were not observed in Ranger II;
- the incidence of cellulitis (on the knees, legs, ankles, feet, hands, or multiple locations) was higher in the Ranger I study than in Ranger II; and
- decline in immune function (IL-2, lymphocyte proliferation) was relatively better preserved in Ranger II when compared with Ranger I.

Because more than energy intake changed in Ranger II, it is not possible to attribute all of the outcome differences between the studies specifically to the differences in nutrition. However, it is quite likely that the increased energy intake played a major role in the improvements noted above.

Discussion: It was fortunate that the study design in Ranger II allowed measurements following a short refeeding episode at the Mid-Mountain Phase. Data from this assessment demonstrated rapid improvement in some of the measures of immune function, hormone levels (e.g. testosterone and insulin like growth factor), and some aspects of cognitive performance. These findings suggest that provision of periods of adequate energy intake and sleep can dramatically improve both mental and physical performance. They give credence to the possibility that the improved outcomes in Ranger II were due in major part to the increased baseline energy provided.

Small losses of body fat imply loss of other bodily constituents and signal a state of metabolic deprivation. There is reason for concern when losses result in a total body fat of less than 10%, especially when losses are rapid. At the final sampling during the Ranger II study there were some individuals with less than 10% body fat. This suggests that some soldiers may continue to be at medical risk of emaciation. Even though immune functions were minimally improved in Ranger II, the possibility of increased health risk for individuals with less than 10% body fat is supported by the continued evidence of multiple impairments in immune functions.

The CMNR is concerned that while information is limited to only a few subjects in the follow-up studies, anecdotal reports indicate that a significant percentage of soldiers reported problems with diarrhea during refeeding. This observation should be followed up on a broader basis as this may indicate that there was some compromise of gut function and/or impaired immune function. Ideally, if further evaluation indicates this to be a widespread problem, an assessment of the problem should be included as a follow up to additional Ranger studies, possibly even through a carefully controlled study in a metabolic unit.

Recommendations: To further address the question of medical risk, the CMNR recommends that comprehensive studies be conducted in a small number of subjects, beginning immediately after their Ranger training has been completed. The subjects should include men with the highest percentages of losses in body weight and body fat.

The post-training studies should include measurements of nutritional and relevant physiological parameters to assess the magnitude of losses in muscle protein mass and function, of lean body mass, and of other nutrient stores. Attempts should also be made to estimate the time required to restore any observed deficits in body nutrient stores.

Attention should be given also to the refeeding diarrhea observed after training, with respect to its possible etiology, the possible presence of steatorrhea, and to the duration of diarrhea.

Nutritionally induced dysfunctions of the immune system usually respond promptly to refeeding. This could be assessed by performing an additional battery of delayed dermal hypersensitivity tests, beginning 7-10 days after the onset of refeeding.

In both Ranger I and II an increase was observed in the battery of enzymes associated with liver function. The cause of this increase should be explored through further research. For example, these enzymes may be derived from muscle tissue and may be associated with the loss of lean body mass. This could be ascertained in a subsequent study of Ranger Training by not only measuring the liver enzymes as in Ranger I and II but also by determining specific isoenzymes of LDH, AST, and ALT at the beginning and end of the Mountain Phase . Data collection on these enzymes and isoenzymes at these time points would provide information before and after the most grueling periods of Ranger Training.

Question 2: Should an even greater increase in energy intake be recommended (consistent with Ranger training goals)?

Answer: It is impossible to answer this question definitively with the data available. However, the results of Ranger II compared with Ranger I suggest a beneficial effect of the increased caloric intake in Ranger II in minimizing loss of body weight and body fat stores. The decrement in physical performance observed in Ranger II was similar to that observed in Ranger I. In contrast, cognitive performance appeared improved during periods of refeeding and additional sleep (Mid-Mountain Phase). However, no direct comparison with Ranger I is possible since data were not collected at a comparable refeeding time. Overall, the caloric supplement appeared compatible with Ranger goals. The value of additional increases in energy intake requires further study.

Discussion: The increase in calories provided in Ranger II compared to Ranger I appeared to have a beneficial effect with regard to minimizing body weight loss and excessive depletion of body fat stores. It appeared however, that performance decrements measured by lift capacity were not systematically changed by the extra caloric supplement provided in Ranger II.

According to the data presented, there was an increased level of energy expenditure in Ranger II versus Ranger I. Although the experimental conditions were not identical, the additional energy intake may have been responsible. This result is similar to that seen in populations where there is an increase in voluntary activity when energy intake levels increase after long-term consumption of sub-optimal energy intakes. In trying to have periods of adequate energy intake included in the training, it may be necessary to take into account an increased level of energy expenditure if kcal intake levels are increased.

Some aspects of cognitive function improved with refeeding and additional sleep (Mid-Mountain Phase). To control for possible differences in initial body weight and body composition, it would be valuable to present data comparing Ranger I and II by including data for each individual for body weight, body fat and lean body mass, pre- and post-study. The data provided suggest a beneficial effect of dietary supplement but the continued decrements in physical and cognitive performance suggest that further increases in caloric intake might well lead to improved learning and performance. In future studies this could be tested by studying sequential Ranger groups in a dose response fashion (two levels of caloric increment or periodicity).

Recommendations: Consistent with Ranger goals the degree of stress required needs continuous reassessment. Based on the outcome of that assessment, periodic refeeding during the course should be considered as a means of enhancing cognitive functioning and work performance. The data from Ranger II with regard to the Mid-Mountain Phase suggest that repeated periods of acute as opposed to chronic caloric deprivation stress are tolerated better by the trainees. These data could also provide suggestions for future studies of acute versus chronic deprivation and performance. Future studies of Winter Rangers who receive higher levels of caloric intake might provide some of these data.

The apparently beneficial effect on cognitive performance of refeeding must be assessed independently of possible beneficial effects of additional sleep (Mid-Mountain Phase). Future designs could separate these effects.

Question 3: Should any specific supplementation of vitamins, minerals, or protein be considered?

Answer: No. The data provided do not suggest any problems with regard to vitamin or mineral nutriture (with the possible exception of hyperzincemia, which was noted as a group mean value in Ranger II). However, there is some question about the adequacy of the actual intake of protein during the field phases.

Discussion and Recommendations: The micronutrient content of the rations appears to be adequate. Nevertheless, some Rangers chose to supplement with vitamins and minerals which they brought to the training program. In additional data analyses, if possible, individuals who used supplements should be compared with those who did not. Future studies of Ranger Training might also consider this as a design point.

Since no information was provided regarding protein intakes during Ranger II as compared to Ranger I, it is difficult to determine if protein intake was "adequate" during all phases of either study. The more hypocaloric the state of the individual, the more protein will be required to minimize negative nitrogen balance. Therefore, the question of protein intake is relevant in considering the data from Ranger II. Supplementation with either additional protein or energy should decrease fat-free mass loss due specifically to lack of protein rather than that due to inadequate energy, particularly at high levels of energy expenditure. It is difficult to ascribe the small reduction in loss of fat-free mass between Ranger I and II to the increased energy intake without knowing if protein intake was held constant or was similar between the two studies. This does not seem to have occurred due to the difference in protein content between the MRE fed in field training exercises in Ranger I for 33 days and the MRE or LLRP plus pouch bread (which provided an additional

12-16 g of protein) fed for 38 days during the field training exercises in Ranger II. Nutrient intake and balances, where they are possible to estimate, should be evaluated, particularly with reference to protein. In addition, changes in the hydration state of the fat-free mass would also have to be taken into consideration to assess changes in protein mass.

The data for all nutrients presented at the meeting were group means. To address the issue of supplementation, especially additional protein, the individuals who were in the extreme quartiles of the distribution for body fat/fat-free mass before and after participation in the program need to be evaluated. For example, will there be an invariant loss in lean body mass? Concerns with possible misidentification of water as lean body mass using dual-energy x-ray absorptiometry (DEXA) methodology suggests that lean body mass loss could be even greater than reported. Perhaps this will be clarified when the doubly labeled water data is available for comparison with the other methodologies used in the study.

The elevated plasma zinc concentrations, noted as a group average during Ranger II, are most unusual and unexpected. In stressful situations of many varieties, plasma zinc values typically decline as a result of zinc sequestration in the liver, where zinc becomes bound to metallothionines, newly induced by cytokines such as IL-1.

Hyperzincemia is a rare and unusual finding, with few known causes. Most commonly, high zinc values are factitious, and caused by zinc contamination of the samples, with needles being a source of the zinc. Familial hyperzincemia is an exceedingly rare condition, and can be discounted as a possibility here. Ingestion of excess zinc can lead to hyperzincemia of several hours duration, and may be an explanation in the Rangers, who were allowed to take unregulated amounts of vitamin/mineral supplements. Many such supplements are known to contain large amounts of zinc. A last possibility is associated with the escape of cellular enzymes into the plasma; many enzymes contain zinc.

The cause of the hyperzincemia can be investigated: a) by checking the needles used in blood sampling to see if they leach out any zinc; b) by reviewing blood collection methods to search out any other cause of zinc contamination; c) by reviewing data of individual Rangers to see if hyperzincemia in a few caused group mean values to be elevated; d) by contacting individuals with hyperzincemia to determine if they took zinc-containing supplements, and finally; e) by reviewing the high enzyme values to determine if any of the enzymes were zinc containing ones.

Future studies would be necessary to assess the value of performance enhancing supplements such as amino acids (e.g., tyrosine, tryptophan, arginine, glutamine), vitamins (e.g. choline), minerals (such as potassium), or other substances such as caffeine, nicotine, etc. Pilot studies (before Ranger field studies) should be used to assess the value of supplements. Muscle biopsies also could be performed in these pilot studies.

Question 4: Are the immunological changes noted related to the plane of nutrition during Ranger training or to other (e.g. sleep deprivation) stressors?

Answer: Some immunological changes noted during Ranger II can clearly be caused by the decreased plane of nutrition. Other concomitant stressors (including loss of sleep; severe, prolonged, and repeated muscular exertion; dermal inflammation and abrasions; and minor infections) could also contribute to the observed immune system derangements.

Discussion: The immunological studies reported by Dr. T. R. Kramer (USDA), CPT R. J. Galloway (WRAIR), and LTC E. W. Bernton (WRAIR) all showed reassuring internal consistency during Ranger II. Further, these new data reflected quite well the various immune system changes seen during Ranger I.

Dr. Kramer's studies in both Ranger I and II, showed reductions in T-lymphocyte functions. These were evidenced by decreased proliferation of Total, Helper, and Suppressor T-cells. Changes were also noted in the cytokines. The *in vitro* release of soluble receptors for IL-2 was reduced. Decreases in plasma IL-6, and decreases in the *in vitro* cellular release of IL-6 were noted also. The immunological decrements found by T. R. Kramer in Ranger II were not quite as large as those seen in Ranger I. The possibility that this between-study difference was due to the increase in food intake during Ranger II was strengthened by findings that transient improvements in all measured T-cell populations occurred immediately after the brief increase in food intake during the first days of the Mountain Phase of Ranger II.

Sleep deprivation was similar during Ranger I & II, and presumably, this stress should have influenced the immune system equally in the two studies. However, the incidence of infections and dermal abrasions during Ranger II was decreased. The reduction of these stressors in addition to the smaller losses of body weight and nutrient stores could, in combination, have contributed to the relatively better preservation of T-cell numbers and functions. The unregulated consumption of vitamin/mineral preparations could also have contributed to the slightly smaller immune system dysfunctions observed in Ranger II.

LTC Bernton's data showing progressive decreases in delayed dermal hypersensitivity (DDH) responses during Ranger II were quite similar to the DDH data he had obtained in earlier Ranger groups. These *in vivo* data give strong evidence for a progressive (eventually quite marked) reduction in cell mediated immunity as multiple stresses accumulated during the 4 phases of training. The reduction in DDH responsiveness could be attributed to the progressive losses of body weight and nutrient stores, as seen in the Ranger trainees, as well as to the other stressors they experienced. However, the contribution of each stressor cannot be differentiated. The increase in food intake during Ranger II did not seem to reduce the measured decrements in DDH responsiveness. Although reductions in DDH responsiveness in Ranger II were shown to correlate with reductions in plasma testosterone and TSH values, this does not prove that a "cause-and-effect" relationship exists between these variables.

LTC Bernton's work also included observations on increases in leukocyte production of superoxide radicals during Ranger II, but also a poorer production of Tumor Necrosis Factor (TNF), a cytokine that triggers acute-phase reactions, and Serum Amyloid A (SAA), an acute-phase reactant protein.

Studies in the Rangers did not attempt to determine if changes occurred in Natural Killer T-cell numbers or functions. These are also highly important components of cell mediated immunity. Further, immunological studies during Ranger II did not attempt to measure any responses involving cellular antigen-presenting activities or B-cell functions. These are important components of humoral immunity. Administration of vaccine antigens in an earlier Ranger study indicated that deficiencies in humoral immunity developed during the course of training.

The possible occurrence of cytokine-induced "acute phase reactions" has not been adequately documented during Ranger studies. This is an important immunological and nutritional question. The increased body temperatures, hypermetabolism, losses of body weight, and muscle mass that are components of the "acute phase reactions" associated with infections, inflammation, and/or severe muscular work could play a part in the losses of body weight and stored nutrients, as seen during Ranger training.

Some indirect evidence for the occurrence of "acute phase reactions" was seen in Ranger I studies. However, the poor cellular production of IL-6 and TNF in Ranger II studies would suggest that "acute phase reactions" were not of major concern in contributing to the observed weight loss. The lowered body temperature measurements (LTC Bernton's data) at the end of Ranger II are also incompatible with an "acute phase response", but they are quite compatible with physiologic responses to prolonged semi-starvation and body weight loss.

In conclusion, the minimal lessening of immune system dysfunctions during Ranger II would probably contribute very little to an overall improvement in resistance against infectious illnesses. At least some of the immunological changes noted during Ranger II could clearly be identified as being related to a decreased plane of nutrition. Other concomitant stressors, including loss of sleep; severe, prolonged, and repeated muscular exertion; dermal inflammation and abrasions; and minor infections, would all combine to produce immune system changes.

Recommendations: Useful additional information could possibly be gained by:

- comparing the weight loss and body fat loss of individual Rangers with their various immunological measurements; this should include individual data from both Ranger I and II, and should emphasize the individuals with greatest weight (fat and lean) and nutrient losses as well as those with the largest immune dysfunctions; and
- adding any data available on the drop-outs to these comparisons, as these data may also prove useful.

If future Ranger Studies are possible, additional data should be gathered on:

- antibody responses to new antigens at various times in the progressively developing immunosuppression;
- possible changes in Natural Killer Cell numbers and functions;
- longitudinal development of body core temperature changes using the tympanic membrane thermoscan technique; and
- baseline and periodic longitudinal studies of key "acute-phase" cytokines, i.e., IL-1, IL-6, and TNF.

Question 5: Are the decrements in cognitive function a cause for concern?

Answer: Despite impressive evidence gathered during this study suggesting that the regimen of Ranger training results in decrements in several areas of cognitive function, it would be premature at this time to draw definitive conclusions and attempt to answer this important question on the basis of data collected during a single study. Further, because a particular cognitive deficit may be of little significance to successful performance in one situation but critical to performance in another, the answer to this question requires a full consideration of the nature of activities in which the student is engaged during training.

Discussion and Recommendations: The data show relatively strong effects of the Ranger training regimen on several aspects of cognitive function, including a 33% decrement in decoding speed, a 7% decrement in memory accuracy (no speed trade-off possible), a 20% decrement in reasoning speed, and a 15% decrement in visual attention (speed and accuracy). Performance decrements were observed beginning with the second phase (Desert) and continued throughout. In particular, attention to detail and concentration were substantially impaired and showed a cumulative effect over the course of training. Visual attention and memory performance did show improvement with a brief recovery period (Mid-Mountain Phase), but performance on decoding and reasoning tasks did not respond to this intervention. Further, although individual data were not reported, measures of variability in performance were relatively small, indicating that these effects were present to a similar degree in all students. Decrements were therefore found to occur even among the most highly motivated individuals. In addition, a trade-off between the time required to perform a task and the accuracy of performance was observed across tasks; the strategy apparently adopted by the student was to attempt to maintain accuracy and minimize error at the expense of increasing response time.

Notwithstanding these impressive findings, this study represents only the first attempt to systematically assess the effects of Ranger training on cognitive function and performance and it is unknown whether the same effects occur in other classes, and if so, to what degree. It is also unknown whether other, yet unmeasured, aspects of psychological and cognitive function necessary for effective performance might be negatively impacted by the stressors experienced during this type of training. Further, several factors that might mediate the functional effects of these stressors, such as student expectations, feedback (awareness of performance decrements), and debriefing, need to be more fully considered. Therefore, data from the present study alone are not adequate to fully answer the question posed to the committee.

Whether those decrements in cognitive performance which ultimately prove to be reliable are sufficiently critical, broad or severe to be a cause for concern is largely dependent on the nature of the activities in which the student is engaged. Ranger training is designed to test the physical and psychological limits of the student under conditions which simulate the demands of combat (i.e., in the presence of multiple severe stressors) and to develop in the student leadership skills important to the accomplishment of all assignments. One objective is to create an awareness in the student, through personal experience as well as observation, that chronic stressors (e.g., extended food or sleep deprivation) will affect mental as well as physical performance. Potential leaders must also develop an awareness that such stressors will compromise the capabilities of even the most motivated soldier. As one researcher noted, despite expectations to the contrary, "There are no supermen." Therefore, it is critical that the training regimen continue to include stressors which result in decrements in cognitive function. However, it must be determined that these effects are transient and will recover with removal of the stressor(s). Further, these decrements in cognitive function should not be induced in severe degree at a time when the safety of the individual student or the group might be compromised, such as during helicopter evacuations. Because performance on attention and short-term memory (decoding) showed recovery with refeeding and additional sleep (mid-Mountain), some concern might be alleviated by including a short recovery period just prior to particularly dangerous and demanding exercises.

Replicating the findings of Ranger II, broadening the range of cognitive functions assessed, and investigating potential mediating factors such as those discussed above should permit a relatively confident response to this important question.

The committee was impressed with the documentation of psychological and behavioral effects in this study. The rationale for selection of individual tasks was theoretically and experimentally sound, and appropriately selected for use in field situations. Tasks chosen for administration were decoding, memory, reasoning, and embedded figures. These tasks varied in their emphasis on attention (automatic versus effortful), memory and judgment, and in their reliance on visual information processing, the ability to check (correct) work, and the availability of feedback to the student. Collectively, this battery of tasks was sufficiently broad to assess a range of cognitive function. The functions studied also appear to be relevant to tasks routinely required of the soldier. Clearly, this type of information should continue to be collected in future studies of Ranger training and the results shared with Rangers during debriefing.

The committee agrees with the recommendation of the principal researcher, MAJ Mays, that scheduling brief periods of recovery should be considered for possible implementation. A hot meal and 8-10 hours of sleep could provide a more desirable balance between the competing goals of maintaining a high level of stress in the student while permitting him to learn about the physical and functional consequences of both acute and chronic stressors through personal experience and observation. Further benefit in this regard could probably be achieved by providing the student with immediate feedback on his cognitive performance during training, and, at the conclusion of training, engaging all students in an extensive discussion of the functional consequences of stressors like food and sleep deprivation, using their own data and those of the cadre as examples, and the implications of these effects for cognitive performance during combat or other demanding assignments.

Future studies should determine the extent to which students are aware of increasing difficulties with their mental performance, and the impact of this knowledge on their confidence, motivation, and performance on future tasks. A related question is whether performance decrements in a student influence that student's perception of performance decrements in other students. How performance decrements are perceived by others in the unit and whether such decrements cause others to question a student's leadership skills, should be addressed.

To what extent the observed accuracy-for-speed trade-off occurs naturally, or is the result of instructions to minimize error, is not known. Regardless, what implications does such a strategy have for performance of assignments which emphasize time? How flexible is this student's approach to tasks with varying emphasis on accuracy and speed?

Future studies should also consider inclusion of additional cognitive tasks to converge on specific cognitive processes (constructs) thought to be most susceptible to the effects of caloric and sleep restriction, and should consider assessment of other modalities, e.g., auditory based tasks.

Procedural questions which were not addressed but should be considered include the following. How should students be prepared for cognitive and physical performance decrements (i.e., What are their expectations)? Should students be told that mental processes including memory and reasoning will be significantly influenced by the training regimen? Should students be debriefed and what is the nature of this debriefing? Would extensive discussion of cognitive (and emotional) effects of the physical and psychological stressors following the course be beneficial?

Through combining the results on sleep deprivation from the two Ranger studies with the cognitive data from Ranger II, the scientists involved in the studies could make suggestions to the Ranger Training Brigade. These suggestions could be utilized by the Ranger cadre during the first days of training to provide the trainees with strategies to optimize their success in terms of sleep and learning. Based on the results from the two Ranger studies, the opportunity exists for future Ranger classes to begin their training with suggested strategies to maximize opportunities for sleep. Given a short sleep period, based on data from the Ranger studies, how should trainees optimize their sleeping time to obtain quality sleep? Similarly, given the sleep deprived state of all trainees, what strategies can be used to maximize learning and mental performance, based on the data from Ranger II? These types of information would put the data collected during these studies to good use to directly enhance the performance of Ranger trainees. It would also provide the opportunity in a future Ranger Study to study the impact of such recommendations.

An issue raised following the previous Ranger study was: How much stress is required to meet program objectives (training goals)? Assuming the stressors imposed during Ranger training are operationally defined, this question will remain unanswered until objectives are stated in a manner which is amenable to establishing quantifiable criteria.

CONCLUSION

The provision of questions by the Military Nutrition Division provides a basis for focus for the committee deliberations. Within the answers to the questions the committee has included not only their thoughts related to the preliminary results presented at the meeting, but also suggestions and recommendations for specific research action related to the questions posed. In Part III of the report, the Committee on Military Nutrition Research presents their overall recommendations and conclusions.

Part III

Committee Recommendations and Areas for Future Research

SPECIFIC RECOMMENDATIONS FOR RANGER TRAINING

The CMNR is of the opinion that the data obtained on weight loss and body composition changes, alterations in immune function, and data on sleep and cognitive function from the Ranger I and II studies, offer unique insights into these changes in physiology and performance that may occur in previously well-nourished and physically-fit individuals. The demanding physical activity combined with limited food intake and limited sleep resulting in a 12-15% average weight loss in a period of about 9 weeks, provide data that would be very difficult to obtain other than in this military training setting. The researchers are commended for collecting this valuable data under demanding conditions. The Ranger Training Command is also to be commended for its interest in evaluating the health risks of this rigorous program designed for training future troop commanders.

The data from these studies are not only valuable for the military in coordinating programs, but also provide valuable insight into other medical conditions such as healthy individuals subjected to severe trauma. The data may also provide information concerning populations of developing countries that are engaged in heavy physical work during periods of food shortages. We urge the publication of these and future studies in the peer-reviewed nutrition research literature so that they may be made widely available to others conducting research in related clinical nutrition fields.

1. The committee recommends the evaluation of the effects of additional sleep ("catch-up") and caloric intake during the course of the training program just prior to physically hazardous training exercises as well as sessions that include

important leadership training experiences that may be equally critical for future Rangers in combat settings. Perhaps a goal of limiting weight loss to not more than 10 % during the 64-day training period should be considered.

2. Since measurements of abdominal girth were shown in the Ranger II study to correlate well with percent body fat in individuals, it is recommended that abdominal girth measurements be used as a standard tool by Ranger trainees within their own groups to monitor health risk due to rapid change in body composition.

3. During cognitive testing in Ranger II it was apparent that trainees were aware of the decline in their performance. However, they may not have been fully cognizant of the degree of this decrement or its implications for performance in a combat setting. To enhance the self-awareness component of Ranger leadership training, the CMNR recommends that immediate and direct feedback on level of performance be given to trainees during the course of training, and that more extensive discussion of this aspect of function take place at the conclusion of training (structured debriefing). Further, because the range and severity of decrements have not been fully identified and characterized, it is recommended that assessment of cognitive and other psychological variables relevant to performance be formally incorporated into future Ranger training.

4. The data collected on sleep, cognition, and nutrition during the Ranger studies should be used to develop recommendations that can be directly given to incoming Ranger trainees to help them minimize the stressors of Ranger Training and be more effective in their goal of gaining leadership qualifications. Trainees would thus begin training armed with strategies that they can employ to maximize their opportunities for learning including the knowledge beforehand of the potential impacts of food and sleep deprivation on their own performance.

AREAS FOR FUTURE RESEARCH

The areas for further research can be divided into three components:

- general research issues,
- questions that can be answered through further analyses of the existing data, and
- questions that can be answered by additional studies.

The CMNR has separated their recommendations for future research into these three components below. However, an issue that the Committee on Military Nutrition Research considers of overriding importance is the appropriate analyses of all variables from both studies with attention to longitudinal analyses of data on individuals. The committee believes that the presentation of the unique data from these studies solely as group means may mask many interesting and physiologically important scientific results. The CMNR realizes that these types of data analyses may require additional state-of-the-art biostatistical techniques and it encourages the Military Nutrition Division to consult with individuals, when necessary, to obtain the additional expertise to perform the appropriate analyses.

General

1. Ranger studies offer the opportunity to collect invaluable information that is of health benefit not only to the Army but also to the civilian population as a whole. The committee strongly encourages continued research with the Ranger Training Classes particularly under varying environmental conditions. This research should address issues that become more apparent with completion of the analysis of the Ranger II study as integrated with the findings from Ranger I.

2. The investigators should refine the data analyses. The data are unique and consideration of data on an individual subject basis should be emphasized.

3. Data from both studies, to the extent possible, should be evaluated on the basis of individual medical and psychological profiles collected prior to the study, followed longitudinally across the phases of Ranger training, and at specific points in time post-training (eg., 30 days, 6 months, 1, and 5 years).

4. Biostatisticians should be identified who can assist with the evaluation of the data from both Ranger I and II studies using state-of-the-art techniques to optimize the use of this significant database.

Suggestions for Additional Analyses of the Ranger I and II Data

1. Adequacy of protein intake, particularly during field training exercises, should be investigated by comparing estimated food intake levels during field exercises with food intake during periods of greater ration consumption. Was protein intake indeed adequate to maintain functional protein mass? Because

of the apparent changes in hydration of fat-free mass further analyses of data should be conducted to determine changes in protein mass.

2. Using the data on the total number of subjects that have been studied to date in the Ranger Training projects, it would be important to determine possible correlations between initial body composition and the outcome physiological variables measured in the studies. The use of multicompartment models that would measure fat mass, skeletal mass, total body water, and protein mass would be desirable. Associations among variables and especially with fat-free mass may also be helpful. These data may also be useful for generating predictors of successful training completion.

3. Post-training, there was evidence that the ten individuals studies gained considerable body weight. The mean body weight 5 weeks post-training was above the pre-training mean weight, with a larger increase in relative amounts of fat to lean. The composition of the weight regained and the length of time to restore lean body mass are important considerations and should be evaluated as this has implications for post-training behavior (i.e., food intake, exercise), susceptibility to infections, and possibly other health implications.

4. World War II studies showed that muscle recovery from severe wounds was slow. Is significant loss of lean body mass in the short period of time of the Ranger studies also slow to recover following refeeding? Reports of individuals following refeeding having problems with diarrhea also raise the question of cell membrane permeability and possibly abnormal fat absorption.

5. Using the data from the two Ranger studies the scientific team is encouraged, to the extent possible, to develop a mathematical model of predictors for success, and risk factors for failure, that can be provided to the Ranger Training Brigade and evaluated through future selective research.

6. Because group average plasma zinc values were elevated, and because dietary intakes of excess zinc can lead to immunosuppression, available data should be evaluated further in an effort to determine the cause of the hyperzincemia. Comments in the discussion of question 3 in Part II provide specific suggestions.

Suggestions for Specific Future Studies of Ranger Training

1. Conduct a future study of U.S. Ranger Training that begins in winter. This will allow the trainees to be followed through the harshest climate in the mountain phase and provide important comparative data on the role of climatic stressors in the situation, as well as evaluating the higher caloric intake normally provided in winter training.

2. Develop a protocol to more completely assess recovery from Ranger Training based on the interesting findings from Ranger II. Would dietary recommendations be effective in reducing the excessive post-training weight gain? A detailed food intake study would probably not be cost effective, however, measurements of body composition and body weight at several time points up to one year post-training coupled with limited dietary records would be beneficial.

3. A small number of people with the most weight loss could be studied after the training course was completed. Perhaps this project could be conducted in a metabolic unit and include muscle biopsies as well as indirect calorimetry to gain additional data during the recovery phase. Such studies possibly could be conducted in collaboration with the Pennington Biomedical Research Center. The project design should focus on individual changes that offer the greatest opportunity to generate data of predictive value for the success of Ranger trainees.

4. Additional immunological studies would be advantageous in the recovery stage. In particular Killer cell numbers and activities, specific cytokines that influence the acute-phase reaction (IL-1, IL-6, TNF) and B cell function should be measured. (See discussion of question 4 in Part II for additional comments on specific suggestions.)

5. In a future follow-up study include additional increments of caloric intake and/or sleep to evaluate the degree of the intensity of training that is necessary to achieve the desired outcome. These studies could help answer the question of the degree of stress necessary to achieve the desired training and to measure the effect on completion rate and trainee performance. It would also be important to evaluate the level of increased voluntary activity. Such observations would help determine if activity increases with additional energy intake as seen in Ranger II when compared to Ranger I. This should be considered under the concept of training rigorously but at a level consistent with achieving the desired learning objectives.

6. Establish a procedure for evaluating the individual participants longitudinally to be able to compare such factors as body weight loss, percent body fat, and various immune responses at the time of reevaluating this training. Perhaps those individuals could be selected as participants who are continuing through the training again. This would provide the opportunity of testing them at the same stage of the training regimen as they were previously tested.

CONCLUSION

In conclusion the CMNR and their advisors found the questions raised by the Ranger nutritional assessment and intervention projects to be of great importance. Further studies offer both improved conduct of Ranger Training and may also be of more general clinical importance for the care of injured and critically ill patients. The Committee on Military Nutrition Research is pleased to provide these recommendations as part of its ongoing activities in assisting the Military Nutrition Division of USARIEM.

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Appendix H

Summary and Recommendations the Workshop Report: Fluid Replacement and Heat Stress, third printing

Submitted January 1994

Committee Summary and Recommendations

INTRODUCTION

Advances in our understanding of the value of carbohydrate-electrolyte solutions have come from information derived from two major fields of study—exercise physiology and sports nutrition—and from research on diarrheal diseases. Research in the first area has been concerned with physical performance, primarily of athletes. Research results have demonstrated that even small fluid deficits have adverse effects on performance through elevated heart rates, reduced sweat rates, and elevated body temperature. Glucose-electrolyte solutions have been found useful in rehydration and in preventing dehydration. Carbohydrate is needed to facilitate sodium and water absorption. Other ions may or may not be needed, depending on sweat losses or losses from the gastrointestinal tract. Advances in exercise physiology also have demonstrated the value of carbohydrate solutions in providing energy for muscular activity in endurance events that last at least 60 minutes and involve vigorous exercise.

Diarrhea is a major, perhaps the most important, contributor to death of infants and preschool children in less-developed countries. Death rates are being reduced around the world through the use of oral rehydration therapy (ORT), which involves the use of carbohydrate-electrolyte solutions and is based on the same basic physiologic mechanism as the rehydration solutions given to athletes, i.e., the provision of glucose to promote the absorption of sodium and potassium ions and of water.

Both these established uses for carbohydrate-electrolyte beverages have potential military applications. Military personnel are often called upon to perform heavy physical activity during training or combat conditions in very hot environments—either dry climates, as in Middle-Eastern deserts, or under humid tropical conditions. The resultant high sweat rates can lead to dehydration. In some cases, the subjects may be acclimated to heat, but in others (for example, in basic training, or in emergency troop deployment to the tropics) they may not, and may thus be vulnerable to extensive electrolyte losses. This problem could be accentuated when personnel have been given garrison or field rations with reduced sodium to meet prudent dietary goals established for the general population in 1989 by the Diet and Health Committee of the Food and Nutrition Board, National Academy of Sciences.

A carbohydrate-electrolyte beverage could be useful in providing glucose to sustain muscular activity in troops involved in heavy physical activity for long periods. Recognizing that the maintenance of an adequate hydration status is dependent on an adequate fluid intake, the military has for a long time instructed troops on ways to maintain a safe supply of drinking water under field conditions. Carbohydrate-electrolyte solutions are useful in rehydration during episodes of diarrhea, especially to counteract acute dehydration that results when diarrhea occurs in conjunction with heavy sweat losses.

FINDINGS FROM THE WORKSHOP PRESENTATIONS

Maintaining an adequate state of hydration is important for the maintenance of high levels of physical performance by soldiers in the field. At a 3% decrease in body weight due to dehydration, there is a substantial decrease in physical working capacity. The maintenance of adequate fluid intake is of primary importance in the prevention of hypohydration that may otherwise occur under such conditions as prolonged air travel, extended working hours, wearing of chemical protective clothing, missed meals, or working in mountainous areas or in hot or extremely cold environments. Increased psychological stress associated with basic or field training exercises or anticipation of combat or actual combat may lead to extreme hypohydration due to decreased voluntary fluid intake. Conscious efforts to increase fluid intake before and during such situations could prevent this condition. Training and the initiation of disciplined programs to increase both voluntary and programmed fluid intake are important preventive actions.

Heavy physical activity, especially in hot environments, and wearing of protective clothing promote sweating and will lead not only to excessive fluid losses but also to associated electrolyte losses. Sodium, potassium, and chloride losses in sweat are affected by temperature, humidity, and state of acclimatization. Febrile conditions or gastrointestinal disturbances, particularly those associated with vomiting and diarrhea, may result in significant fluid and electrolyte losses and require replacement of electrolytes in addition to fluid. Gastrointestinal losses may also include hydrogen ion, bicarbonate, magnesium, and other cations and anions, depending on the cause of the losses and the severity of the disturbance.

Glycogen depletion from muscle and liver may result from prolonged physical exercise—more than 60 or 90 minutes at 60% to 70% of exercise capacity or several hours at lower exercise intensities. Such depletion may be aggravated by poor nutritional intake of carbohydrates, inadequate periods of recovery from previous glycogen-depleting exercise, and sustained negative calorie balance. Under these conditions, soldiers may benefit from consuming fluid replacement beverages containing carbohydrates. This is particularly true if food intake is inadequate, resulting in significant caloric deficit or limited carbohydrate intake. The resultant reduced muscle and liver glycogen content will result in earlier fatigue and slower recovery.

It is evident from the research reported at this workshop that a fluid replacement solution may play an important role in preventing fluid, electrolyte, and glycogen depletion, thereby maintaining or improving a soldier's performance. It is also evident that the composition of the replacement fluid might well vary, depending on the physical demands of the military activity and the environmental conditions under which the activity is undertaken.

Water intake is the primary requirement to ensure adequate hydration during psychological and environmental stress not associated with intense physical activity and during sedentary activity at high altitudes. If a normal meal pattern is established and fluid is consumed, the body's balance is restored.

Palatability of the fluid replacement solution is important to ensure compliance. This may be enhanced by appropriate coloring and flavoring. The solution should also be compatible with halogens to make it possible to use halogen-treated water in the preparation of the solutions.

AREAS FOR FUTURE RESEARCH

The participants whose papers appear in this volume provided an excellent review of the current state of knowledge on fluid replacement and stress. These proceedings will provide investigators and product formulators with important guidance in the development and testing of electrolyte-carbohydrate–containing fluid replacement products for use by the military. Continued research is needed on energy, electrolyte, and fluid requirements in different environmental and operational conditions that require different types of physical activity. More studies are also needed to provide us with a better understanding of (1) the factors affecting liver and muscle metabolism and injury during heat stress, and (2) the factors that are important in preventing muscle injury during heat stress and in enhancing muscle recovery. The following issues raised at the workshop could lead to a better understanding of the appropriate composition and usage of a fluid replacement beverage:

- What are the effects of food in the small intestine on fluid and electrolyte absorption? How are fluid and electrolyte absorption affected relative to timing of meals?
- What are the effects of hypohydration on the absorption of electrolyte-carbohydrate solutions?
- What factors regulate depletion of muscle and liver glycogen stores during negative caloric balance or prolonged physical activity?
- What is the role of glycogen depletion in the fatigue of different muscle groups? What other factors related to beverage composition determine muscular fatigue?
- What factors determine the rate of glycogen depletion and resynthesis? There is a need to obtain quantitative data on the effects of feeding and the provision of electrolyte-carbohydrate solutions in maintaining glycogen stores and enhancing replenishment of glycogen stores following glycogen-depleting physical activity.
- What are the effects of fluid and electrolyte deficits combined with elevations in body temperature on cognitive and mental function?
- What factors need to be considered in product development and water purification techniques to provide compatible systems for field use under a variety of environmental and operational conditions? Factors such as halogen or other purification requirements and the composition of local water supplies need to be considered in relation to formulation of practical electrolyte-carbohydrate mixtures.
- What effect would result from the provision of an electrolyte-carbohydrate replacement solution on soldiers who previously consumed a low-sodium diet?
- Will the addition of specific amino acids such as glycine be beneficial in enhancing sodium and water absorption?

RECOMMENDATIONS

When used appropriately, electrolyte-carbohydrate–containing beverages appear to have the potential not only for maintaining but also, possibly, for enhancing performance and endurance in a variety of military situations. The specific needs for water, electrolytes, and carbohydrate may vary somewhat depending on the specific circumstances in which the solution is used. The ideal solution would be one that could be diluted in different ways to meet the relative specific needs of the personnel.

The goal of using such a solution should be to maximize fluid intake, replace electrolyte losses, and provide a carbohydrate source for energy and rapid replenishment of muscle and liver glycogen stores during and following physical activity. The use of an electrolyte-carbohydrate–containing beverage may be applicable to a number of circumstances in the military such as the following:

- Maintaining adequate fluid intake prior to military operations during which voluntary dehydration is probable.
- Providing fluid, electrolyte, and carbohydrate replacement during physical work in a variety of environmental conditions, including high temperatures, humidities, or wearing of chemical protective clothing. In such situations, sweat rates are high and account for large fluid and electrolyte losses.
- Providing rapid rehydration following heavy or prolonged physical work, thereby facilitating recovery from heat injury.
- Providing carbohydrate during and following physical activity to maintain plasma glucose concentrations, furnishing carbohydrates for energy, and enhancing replenishment of glycogen stores during postoperational recovery.
- Replacing gastrointestinal losses due to vomiting or diarrheal diseases.

The committee recommends that the Surgeon General of the Army evaluate the use of electrolyte-carbohydrate fluid replacement products as an aid to maintaining proper hydration of soldiers during periods involving psychological and environmental stress and also assess the effectiveness of these products in maintaining or enhancing both physical and cognitive performance during training activities and field operations.

Physical demands and adverse environmental conditions that occur during military training and operations may lead to any one or all the conditions summarized above. In view of this, the committee concludes that there are circumstances in which the performance of military personnel would be improved by appropriate use of electrolyte-carbohydrate solutions under field conditions.

Below are the committee's recommendations developed following the workshop:

- The solutions should provide approximately 20 to 30 meq of sodium per liter, 2 to 5 meq of potassium per liter, and chloride as the only anion.
- The carbohydrate content should be provided as glucose or sucrose, malto-dextrin, or other complex carbohydrate in a concentration of 5% to 10%.
- The value of additional magnesium, bicarbonate, and phosphate to compensate for gastrointestinal losses due to diarrhea or other gastrointestinal disturbances should be determined.
- The promotion of fluid intake with such palatability and psychogenic aids as flavorings and colorings should be evaluated with respect to the promotion of fluid intake. The components of the solution must be compatible with halogens or other water purifiers.
- A variety of training and field operations should be considered as a means for evaluating the effectiveness of prototype electrolyte-carbohydrate–containing solutions under the following conditions:

  - When soldiers are in significant negative caloric balance.
  - Under conditions of hypohydration.
  - When the solution is the principal beverage available.
  - Under conditions of environmental extremes, especially those conducive to stress. Interventions for prevention and therapy of heat-related disorders should be evaluated.
  - When used by soldiers previously on a low sodium diet (less than 3 g/day) who are suddenly exposed to hot or humid environments and who are performing heavy physical activity.
  - Under field conditions when halogen-treated water is likely to be available. Do any of the components in the prepared solution interfere with purification of the water? Is the resulting beverage sufficiently palatable to ensure an intake adequate to prevent significant hypohydration?

Appendix I

Conclusions and Recommendations from the Workshop Report: Food Components to Enhance Performance

Submitted May 1994

Conclusions and Recommendations

CONCLUSIONS

As stated in Chapter 1, the Committee on Military Nutrition Research (CMNR) was asked to respond to six specific questions dealing with the potential for food components to enhance performance for military personnel in combat settings. The committee's responses to these questions appear below. The committee further reviewed the current knowledge base regarding specific categories of food components that were identified by Army scientists as having potential to enhance performance in light of the classification of ergogenic aids and the mechanisms of action as discussed by John Ivy (Chapter 12). Substances that may optimize physical performance are frequently referred to as ergogenic aids (Chapter 12). These may be divided into five categories: (1) mechanical, (2) psychological, (3) physiological, (4) pharmacological, and (5) nutritional. The mechanisms by which foods or food components may act as ergogenic aids as discussed by Ivy are (1) acting as central or peripheral stimulants, (2) increasing the storage or availability of limiting substrates, (3) acting as a supplemental fuel source, (4) reducing or neutralizing metabolic by-products, and (5) enhancing recovery. Each food component was also reviewed in light of the time frames and military scenarios drawn up by Army scientists (see Appendix A). The recommendations and conclusions drawn about the potential for these food components to enhance performance are included in the specific committee recommendations that follow.

GENERAL CONCLUSIONS

General Concepts of Performance Enhancement

The first consideration in maintaining or enhancing performance is to endeavor to insure that troops are in a well-hydrated, rested and well-nourished state-including optimal amounts of all essential micronutrients, plus the best in military training, both physical and mental, in advance of anticipated periods of stress. Under these circumstances performance is unlikely to be improved in the absence of the imposition of military operations which impose physical or mental stress.

Obviously battlefield situations are not free of stress. Under these conditions troops are frequently deprived of sleep, apprehensive, haven't eaten sufficient food to meet their energy expenditures, dehydrated to varying degrees and exposed to environmental extremes of heat, cold, altitude, etc. which impacts on their physical and mental state. Given these conditions, enhancement of performance is more likely to be restoring performance to non-stressed baseline than to improvement over that expected from well-nourished and well-rested troops. The military Science and Technology Objective (STO) of enhancing performance by 10-15 percent is more realistic in short term enhancement of performance under stress than to obtain super performance from troops in a well-fed, well-rested state.

While some of the food components considered in this report may be used at usual dietary levels (caffeine, carbohydrate) others are likely to be at levels of intake that may be considered pharmacological. These components may be provided in operational ration items designed to be used at specific times and provide short-term enhancement through increased vigilance, reduced feeling of fatigue, improved mental state, etc. The enhancement capability of a component likely will have a threshold which must be met to have a benefit and will also likely have a "wear out" when the stimulus can no longer overcome the adverse effect of the stress. In researching the effectiveness and safety of these pharmacological components it will be important to determine these levels and time periods to evaluate both safety and efficacy.

It is also noted that some of these helpful nutritional effects may be maximized by the additional use of conventional over-the-counter drugs that block the intracellular formation of stress-induced prostaglandins, which contribute importantly to many symptoms and the ill effects of stress.

Food Components or Nutrients that Offer Potential to Enhance Performance

The following food components have potential for enhancing performance under certain circumstances that may be encountered in military operations.

- **Carbohydrates.** The role of carbohydrate as a fuel source for extended physical activity is well-known. Increased storage of glycogen prior to extended physical performance through consumption of high-carbohydrate meals and consuming carbohydrates during an extended physical activity as a means of increasing performance is well established. Studies with soldiers in military activities are less clear but likely relate to the more intermittent nature of the physical activity, in comparison with the extended moderate-to high-level physical activities of athletic competition. The value of carbohydrate supplementation in extending physical performance is usually demonstrated after 60–90 minutes of continuous activity at 60 to 70 percent of maximal oxygen uptake ($\dot{V}_{O_2\,max}$). Moderate to heavy physical activity of a lesser time period followed by rest or reduced activity does not usually demonstrate a value for carbohydrate supplementation during the activity.

The potential role for carbohydrates in affecting such behaviors as mood, performance, and satiety, with emphasis placed on sensorimotor and cognitive performance as discussed in Chapter 18, is worthy of further consideration. Mood changes that may affect motivation to operate under stressful conditions are an important consideration. These stressful situations, such as combat, may unmask performance deficits that are not apparent under nonstressful conditions. It also should be emphasized that meals containing protein and carbohydrate demonstrate more beneficial effects than meals that are nearly protein-free. The behavioral effects seen are usually time context dependent. Snacks (providing combinations of protein and carbohydrate) may have utility in enhancing performance between meals. Research in evaluating the benefits of supplemental carbohydrates on performance should include the more subtle evaluations of motivation and coping in addition to the simple cognitive and sensorimotor measures.

Evaluation should be made of the potential performance-enhancing benefits of supplemental carbohydrate and carbohydrate-containing snacks on physical and cognitive performance, including mood and motivational effects.

- **Caffeine.** Caffeine exerts its central nervous system-mediating effects by blocking adenosine receptors. Its stimulant effects when compared with those of other drugs such as amphetamines are weak, but most studies to date suggest that caffeine tends to delay sleep and reduce the deterioration of performance associated with fatigue and boredom. Caffeine at higher doses reverses sleep deprivation-induced degradation in cognitive performance, mood, and alertness—important considerations in extended military operations in subjects who report low levels of caffeine intake. The principal side effects include nervousness/jitteryness and decreased sleepiness, which may persist for several hours.

Caffeine definitely should be considered in developing performance-enhancing rations or ration components. Caffeine is safe as a component of food at doses required to overcome sleep deprivation and has been included in diets in coffee and many soft drinks. Since many soldiers may not normally drink coffee, a mechanism for including caffeine in another ration component that can be selectively used when the situation requires should be evaluated. It appears that doses of 300–600 mg/70-kg person will achieve the desired stimulus in those nonhabituated to caffeine; additional research needs to be conducted to determine the effects of this level of caffeine in those with higher habitual intakes.

- **Tyrosine.** The amino acid tyrosine is the precursor of the neurotransmitters dopamine, norepinephrine, and epinephrine. Under highly stressful conditions, the availability of tyrosine may be rate limiting for the synthesis of these neurotransmitter products. The observation that the functioning of catecholaminergic neurons can be precursor dependent is the basis for the hypothesis that tyrosine will mitigate the adverse effects of acute stress, because such neurons regulate, in part, the behavioral, cardiovascular, and neuroendocrine consequences of stress.

A series of studies in animals has demonstrated that the performance decrement observed in highly stressed animals can be restored by tyrosine supplementation. Studies in humans as well as animals suggest that the amino acid tyrosine may have beneficial effects on humans that are subject to acute stressors. The adverse effects of hypoxia, cold, body negative pressure, and psychological stress have been reduced by treatment with tyrosine. Research is needed to define methods of administration and the effective and safe levels of tyrosine required.

- **Choline.** Choline and choline-containing compounds are critical for a wide variety of processes within the body, including acting as a messenger within the cells and as neurotransmitters in the nervous system controlling muscle contraction, providing methyl groups in a variety of intracellular reactions, acting as a component of triglyceride transport, and participating in the immune response. The best-known function of choline is as a component of acetylcholine, an important neurotransmitter.

Free choline and choline-containing esters are present in a wide variety of foods in the human diet. The usual intake is estimated to be in the range of

200–1,000 mg per day. There is no Recommended Dietary Allowance (RDA) for choline in humans, but intake of 500 mg/day results in decreased plasma choline and phosphatidylcholine concentrations. Diets deficient in choline produce liver dysfunction within 3 weeks, resulting in massive triglyceride accumulation in the liver and abnormalities of plasma levels of liver enzymes.

There is evidence that diets low in choline reduce muscle performance. Dietary choline supplementation of individuals with normal intakes during a 20-mile (32-km) run improved the run time by 5 minutes and prevented the drop in plasma choline levels normally associated with the run. Placebo-controlled, randomized, double-blind trials are needed to determine whether choline supplementation will enhance performance of military personnel undergoing rigorous activity in the field.

Choline supplementation enhances memory and reaction time in animals, particularly aging animals, and enhances memory in humans. Although the mechanisms for this are unclear, there are indications of alterations of the anatomy of brain cells. Carefully controlled laboratory studies with human subjects may suggest field studies to evaluate cognitive performance enhancement in stressful field situations.

With the diversity of functions of choline in the body, there is ample reason for interest in reviewing its possible value in maintaining or enhancing performance of the soldier. Since choline is a normal constituent of many foods and can safely be used at the high usual levels of intake, it is worthy of evaluation to determine whether it may enhance either the physical or the cognitive performance of soldiers who are functioning in a stressful environment.

Other Food Components of Theoretical Importance but Low Probability of Improving Performance

On the basis of a review of information presented at the workshop and review of background materials, it is concluded that the following materials have some theoretical importance but offer a very low probability of demonstrating an improvement in performance under conditions anticipated in military operations.

- **Carnitine.** Carnitine is important metabolically in exercising muscle. Carnitine functions as a transportable high-energy compound that can be reformed without the use of ATP. It acts as a storehouse of high-energy compounds, stimulates fatty acid oxidation, transports acylcoenzyme A (acyl-CoA) across membranes, prevents the accumulation of lactate, and stimulates carbohydrate and amino acid utilization. These functions have led to the hypotheses that supplementation of free carnitine, acetylcarnitine, or propionylcarnitine theoretically might enhance the oxidation of fatty acids during exercise, thus sparing the use of muscle glycogen, delaying the onset of fatigue, and enhancing exercise performance.

Most Americans consume 50–100 mg of carnitine per day, with some consuming three times that amount. Carnitine appears to be safe, but there is little evidence to suggest that higher amounts are beneficial to healthy individuals. Carnitine has been extensively researched, and at this time there is no conclusive evidence that carnitine supplementation is helpful in enhancing physical performance during exercise.

Its importance metabolically in exercising muscle indicates that research on its use should be followed. It is not recommended for consideration in military ration development at this time.

- **Structured lipids.** Structured lipids are defined as fats that are synthesized from mixtures of long- and medium-chain fatty acids. Therefore, they are differentiated from typical dietary fats by the presence of medium-chain fatty acids (5–10 carbon atoms). Their potential as a performance-enhancing ingredient is based on the hypothesis that glycogen utilization during exercise may be spared by the rapid oxidation of the medium-chain fatty acids. Since the medium-chain fatty acids in the diet are delivered directly and rapidly to the liver via the portal circulation, their metabolism in the liver produces the ketone bodies acetoacetate and ß-hydroxybutyrate, which would circulate to the muscle and be oxidized, sparing glycogen.

The nutritional advantages of structured lipids have been demonstrated mostly in individuals with such stresses as burns, trauma, and infection. Research to date has not supported the hypothesis that the supplements of structured lipids will spare glycogen utilization during exercise, which is more closely related to the objective of enhancing physical or mental performance during military operations. In the absence of new data that demonstrate potential in this area, the inclusion of structured lipids in rations or food components for improving performance is not recommended.

ANSWERS TO THE QUESTIONS POSED TO THE COMMITTEE

The committee has answered the six questions posed by the Army in light of the general conclusions described above. These answers are further elaborated in the recommendations that follow.

1. Is enhancement of physical and mental performance in "normal," healthy, young adult soldiers by diet or supplements a potentially fruitful approach, or are there other methods of enhancing performance that have greater potential?

Emphasis should be given to making sure that troops are adequately hydrated and fed prior to military operations. There is little evidence from current nutrition research to suggest that soldiers already consuming nutritionally adequate rations as specified in the Military Recommended Dietary Allowances (MRDAs) will show significantly improved performance when nutritional supplements are added (as differentiated from pharmaceutical levels of some food components). Troops going into operational situations are presumably in good physical condition and have been consuming adequate amounts of military rations to meet their nutrient needs. Individual vitamin and mineral supplements are unlikely to improve performance under these circumstances. Soldiers who have been deprived of adequate food intake for a period under the pressure of military operations would likely benefit from receiving additional food to overcome the caloric deficit before entering another operation. Similarly, if they have been deprived of adequate sleep or rest because of extended physical activity, an opportunity to sleep or physically rest would help restore performance to normal levels.

Stimulants such as caffeine may help in the short term to overcome the effects of physical and mental fatigue when continuous operations are required.

2. The Army Science and Technology Objective (STO) states: By FY98 demonstrate a 10–15 percent enhancement of soldier performance in selected combat situations through the use of rations/nutrients that enhance caloric utilization and/or optimize the physiological levels of neurotransmitters. (Army Science Board, 1991).

Is the level of enhancement identified in this STO reasonable with the current scientific knowledge?

The Army Science and Technology Objective (STO) of demonstrating a 10–15 percent enhancement of performance through specific ration or nutrient consumption by Fiscal Year 1998 is overly optimistic, particularly if this is expected as enhancement over the level achieved by normal, well-fed, physically fit soldiers. However, if enhanced performance is defined as restoring or preventing all or part of the decrease in performance that is usually encountered over extended field operations, then there may be opportunities to achieve this objective.

Current studies of troops in extended field operations show that troops tend to reduce food intake, lose weight, and in some instances dehydrate. Overcoming these deficits is more likely to maintain performance. Since only modest dehydration will result in reduced performance, ensuring adequate fluid intake offers the best opportunity to overcome potential performance deficits. Adequate food intake to meet caloric needs also will help maintain high levels of performance. Under conditions of extended moderate physical activity, carbohydrate supplementation to maintain muscle glycogen levels can extend the ability to perform at this activity level. Simply eating frequent meals may accomplish this. Stimulants such as caffeine may also temporarily maintain physical and cognitive performance.

3. Which food components, if any, would be the best candidates to enhance military physical and mental performance?

Food components that would help provide energy sources to large muscles would be most likely to enhance or maintain performance. The proper use of carbohydrate supplements for persons engaged in continuous, moderate physical activity over at least 1.5 to 2 hours has the ability to extend the time to exhaustion. Caffeine has also been demonstrated to improve physical and cognitive performance. Tyrosine may also benefit cognitive performance under certain circumstances. Choline has shown some possible benefit in improving performance over extended periods of physical activity. Studies with marathon athletes need to be carefully reviewed relative to these applications to military operations. Soldiers in military operations seldom are required to perform at a similar continuous level of physical activity and over the extended time period as athletes in marathon events.

4. Should the mode of administration be via fortification of the food in rations, supplemented via a separate food bar or beverage component, or administered in a "vitamin pill mode"? Is palatability a significant issue in this type of supplementation?

The answer to this question depends not only on what food component or individual nutrient is under consideration but also on issues of safety and efficacy that have not yet been addressed. Depending on the circumstances, carbohydrate supplements can be delivered effectively in either beverages or snack bars. Caffeine is currently widely consumed either in beverages or in pill form, as a means of enhancing wakefulness and alertness. It could easily be added to snack bars or food items, but because of adverse reactions to caffeine in some individuals as well as religious proscriptions, this would be less desirable. It is premature to answer the question for individual nutrients such as tyrosine, tryptophan, and choline. Their effectiveness depends on large increases in plasma levels and is reduced when consumed as part of a normal meal containing protein and carbohydrate. Conversely, their safety is likely to be highest when these substances are consumed as supplements to a meal. The safety of these substances as single supplements when given in large enough doses to be effective has not yet been demonstrated.

5. Are there specific ethical issues that need to be considered with this type of research?

The ethical issues depend upon the nature of the enhancement. When the safety of the use of the ration is not an issue, informing the soldiers about the ration and its purpose should suffice.

If the component(s) is used at a pharmacological level, the criteria for evaluating the safety of the component as a drug should be met. Soldiers should be informed of its benefits, and possible side effects and should be educated concerning its condition of use. Research needs to proceed through proper stages of safety and efficacy evaluation before trials on large numbers of troops are conducted. Issues related to ethnicity, gender, and religious beliefs need to be considered, and evaluation and follow-up on any reported adverse or side effects must be conducted.

The best guidelines for this research would be U.S. Food and Drug Administration (FDA) guidelines for research on proposed new drugs.

6. What regulatory issues must be considered with the types of food components that are being evaluated by the Army?

The considerations for the approval of food additives are well developed by John E. Vanderveen in Chapter 23. The most important consideration is the demonstrated safety of the material in question. The general approach to demonstrating safety is well spelled out in the FDA's Red Book (Food and Drug Administration, 1982). A further consideration is the matter of whether the uses considered during this workshop represent usage as a "food" or as a "drug." Different regulations control each class of materials. Further, if a substance is classified as a "drug," then not only must safety be demonstrated but data showing efficacy must also be presented.

It would seem critical for the military to follow the same requirements that the FDA would require for general use of a component in the civilian population. Therefore in considering the components other than caffeine and carbohydrates that have been discussed as agents capable of enhancing performance, it is important to recognize that none of these materials has been demonstrated to be "safe," notwithstanding the fact that all of these agents exist in natural foods at levels required for potential effects. Importantly, the proposed uses (to enhance performance) require exposure levels that are in excess of what would be consumed in foods.

It would seem that the intended uses as performance enhancers would classify the compounds in question in the drug category. The testing requirements are not necessarily more stringent for a drug; in fact, as noted by Dr. Vanderveen, a drug classification permits a benefit-risk consideration that is not possible for a food category consideration. Thus, it would be necessary to generate data demonstrating minimal risk from the exposures expected and data clearly demonstrating a benefit from the proposed doses.

RECOMMENDATIONS

General

1. On the basis of data presented at the workshop, the Army's prior selection of carbohydrate, caffeine, and tyrosine as food supplements that may enhance performance is fully justified. It is recommended that research with all three should continue.

2. The utility of caffeine in reversing the degradation in cognitive performance, mood, and alertness associated with sleep deprivation that has been widely explored at USARIEM and elsewhere is well understood. It is recommended that future research with this compound explore and attempt to categorize individual differences in responses to caffeine as well as the issue of expectancy and placebo effects.

Recommendations Regarding Food Components Proposed by the Army

On the basis of the papers presented by the invited speakers, discussion at the workshop, and subsequent committee deliberations, the Committee on Military Nutrition Research recommends the following:

1. The following components have clearly demonstrated their ability to enhance performance under appropriate simulated conditions and should be evaluated in appropriate delivery systems.

Caffeine. Caffeine functions as a weak stimulant that, in low doses, tends to delay sleep and reduce the deterioration of performance associated with fatigue and boredom. At higher doses caffeine reverses the sleep deprivation-induced degradation in cognitive performance, mood, and alertness. The long experience with the use of coffee suggests that caffeine is *safe* at levels required to achieve the desired effects, and its effects are reversible over time. **The primary issues that need to be answered in providing caffeine are the appropriate carrier that should be used to provide the supplement and the amount required to achieve the desired benefit in those both habituated and nonhabituated to it.** Since it would not be desirable to inhibit sleep when operations permit, the timing and availability of the caffeine-containing food component should be evaluated.

Carbohydrate. Carbohydrate is an important fuel source and is particularly important for enhancing extended continuous physical activity. The potential role for carbohydrate in affecting such behaviors as mood, performance, and satiety relating to sensorimotor and cognitive performance has not been as thoroughly evaluated. Many studies have been carried out with carbohydrate supplements, with the major emphasis on physical performance. **The committee recommends that this line of research at USARIEM should be continued. However, emphasis should be shifted to the effect of the macronutrient composition of meals and supplements on the affective domain, including such aspects as mood, perceived fatigue, and motivation.** Hedonic properties and the timing and setting of meals and supplements are important variables to be considered, as are food preferences and aversions related to race, ethnicity, geography, and gender. Carbohydrate-containing snacks, which also provide sufficient protein, should be evaluated as a means of overcoming fatigue and improving mood and performance. Research to evaluate the performance-enhancing potentials of such products should be conducted not only as a means of potentially improving performance in the short term but also as an aid in overcoming some of the caloric deficits usually noted for troops in field operations. It is also suggested that the possibility of providing caffeine in such a product may define a product that could be used in a particularly stressful time to enhance performance.

2. The following components are suggested for further research on the basis of their importance in energy metabolism and/or neurotransmitter actions in the body.

Choline. On the basis of its diverse functions in the body, both in physical performance and in cognitive function, and limited studies demonstrating potentially improved performance in extended physical activity, in cognitive function in animals and humans, and its relative safety, the committee believes that choline should be evaluated for its performance enhancement potential. **The committee recommends that choline should be added to the list of food supplements that have potential to enhance performance and that are being evaluated at the U.S. Army Research Institute of Environmental Medicine (USARIEM).** It is suggested that carefully controlled laboratory studies with human subjects be conducted initially, the results of which may suggest field studies that could be used to evaluate enhanced physical and/or cognitive performance under stressful field conditions.

Tyrosine. Research has demonstrated that tyrosine may be rate limiting for the synthesis of neurotransmitter products under highly stressful conditions. Animal studies and limited human studies have demonstrated that tyrosine may have beneficial effects in overcoming the adverse effects of acute stressors. These data are encouraging and demonstrate that additional research should be conducted under carefully controlled conditions to further define when tyrosine may be beneficial in reversing acute stress. The research with tyrosine currently being carried out at both USARIEM and the Naval Medical Research Institute is exciting. **The committee recommends that this research be expanded, with more emphasis placed on safety, interactions with ration consumption, stress, and field studies.** Data are required on the safety of tyrosine use at levels required for efficacy. Since the effect of tyrosine appears to be pharmacological, the FDA protocols for demonstrating safety and efficacy should be considered. Evaluation of the proper method of delivering an effective dose of tyrosine to affected troops would also be required.

3. The following compounds have a low probability of enhancing performance through their use in military rations.

Carnitine. Because of its importance metabolically in exercising muscle, research in the exercise physiology literature should be monitored, but carnitine is not recommended for consideration in performance enhancement ration development and evaluation by the military until it is demonstrated that carnitine supplementation over that normally supplied in usual military rations has some value.

Structured lipids. There are no data to support the fact that structured lipids spare glycogen utilization during exercise and therefore support improved performance. It is recommended that structured lipids not be further evaluated as a performance-enhancing component of operational rations.

Specific Recommendations

Tyrosine. Although tyrosine has been demonstrated to reverse the effects of certain acute stressors, some critical issues remain to be addressed before it can be recommended for use in enhancing the performance of acutely stressed military personnel. These issues, as outlined by Harris R. Leiberman (Chapter 15), are as follows:

1. demonstrating the generalizability of tyrosine effects across a wider range of stressors,

2. establishing a dose-response function for tyrosine's beneficial effects,
3. determining whether tyrosine has efficacy in chronic stress paradigms,
4. determining the safety of tyrosine administration,
5. assessing the risks and benefits of acute versus chronic administration of tyrosine, and
6. determining the most appropriate method for providing tyrosine supplementation.

Choline. Both clinical and basic research into choline and its effects on the body may have relevance for the military. Several clinical studies are obvious:

1. studies to determine whether choline supplementation enhances endurance and muscle performance, and
2. studies to determine whether choline supplementation enhances intellectual performance and whether this alters performance of soldiers in the field.

Carbohydrate supplements. Since carbohydrate supplements have been shown to enhance performance in athletes performing at moderate to heavy levels of physical activity for extended periods of time, it is desirable to evaluate various military operational scenarios to determine whether and when a carbohydrate supplement would be advantageous. Suggested areas are:

1. continuous load carrying at 50–70 percent maximal oxygen uptake for 1–2 hours without resting, and
2. sleep-deprived states when moving into simulated-combat situations.

Another possible area of research would be to determine the amount of protein needed in relation to carbohydrate to prevent the "perceived fatigue" effect reported with carbohydrate intake.

Other Areas that Offer Research Potential

- While tryptophan was extensively used by many individuals, serious safety concerns led to its being banned from use. Depending upon federal regulatory guidelines, tryptophan may at some point offer research potential in the area of sleep promotion. Issues of mode of administration and dose would be areas of significant concern for military research with tryptophan.
- Laboratory research indicates heightened self report of fatigue after ingestion of high-carbohydrate, low-protein supplements. Studies of carbohy-

drate/protein ratios in supplements also offer research potential for sleep promotion.

- Limited data from laboratory studies suggest that the buffering effects of sodium bicarbonate ingestion on muscle pH changes during physical exercise offer potential for further research.
- Glycerol is another substance that, although not specifically covered in this workshop, may warrant further investigation as a dietary supplement to enhance performance.
- Likewise, while not specifically discussed in the CMNR workshop, there are reports that carbohydrate supplementation is beneficial in improving performance at high altitude.
- Although this report has emphasized the specific isolated food components identified by the U.S. Army, and thereby focused recommendations regarding these components on a component-by-component basis, further research would need to include careful investigations of the interactions among any components as well as the interactions of regular dietary levels of caffeine and carbohydrates with performance-enhancing food components.
- Symptoms that frequently occur during stress (including headaches, myalgias, somnolence, and reduction in food intake) contribute importantly to decrements in performance. Carefully controlled studies should be considered during military-type stresses of the ancillary use, prophylactic and/or therapeutic, of common, symptom-treating, over-the-counter drugs that block the cytokine-induced intracellular production of prostaglandins, that is, drugs such as aspirin or ibuprofen. Prostaglandin blockade with such drugs could not only reduce symptoms to improve performance but could also have the ancillary nutritional benefits of improving appetite and reducing the hypermetabolic loss of body nutrients and muscle protein known to be associated with prostaglandin release.

AREAS FOR FUTURE RESEARCH

The Committee on Military Nutrition Research recognizes the potential value for performance enhancement in combat settings and suggests a number of areas for future research within the military. The CMNR believes that the military services, through their pool of volunteer personnel, offer an excellent and often unique opportunity to generate research data and statistics on the nutrition, health, and stress reduction in service personnel. These findings can be directly applied to improving both the health and the performance of military personnel and those of the general U.S. population.

1. Much of the research needed to establish the safety of large doses of tyrosine and potentially choline needs to be carried out with rats. Amino acid, neurotransmitter, and metabolite levels need to be measured in specific brain nuclei, and many other animal studies are needed including gross and microscopic pathologies in both short-and long-term experiments. Possibly this could be accomplished through the Army funded neuroscience research at the Pennington Biomedical Research Center, Baton Rouge, Louisiana, in support of the human studies at USARIEM.

2. Performance, including cognitive, emotional, and physical aspects, is of crucial importance to all service branches. **It is recommended that an interservice committee be established to coordinate and facilitate research and development activities in this area.**

3. **A final general recommendation is to focus nutrition/performance research on diet/stress/immune function relationships in both acute and chronic situations.** It would be desirable to relate the research, at least in part, to researchable issues raised by the two Ranger studies. Immunological studies should include studies of humoral immunity, cellular immunity, and plasma cytokine concentrations before, during, and after the period of stress.

The Committee on Military Nutrition Research is pleased to participate with the Division of Nutrition, U.S. Army Research Institute of Environmental Medicine, U.S. Army Medical Research and Development Command, in programs related to the nutrition and health of U.S. military personnel. The CMNR hopes that this information will be useful and helpful to the U.S. Department of Defense in developing programs that continue to improve the lifetime health and well-being of service personnel.

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